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(71) Applicant (for all designated States except US): <b>UNIVERSITY OF CINCINNATI [US/US]; Mail Location 627, Cincinnati, OH 45221-0726 (US).</b>			
(72) Inventor; and			
(75) Inventor/Applicant (for US only): <b>BALASUBRAMANIAM, Ambikaipakan [US/US]; 2706 Lawyers Pointe Drive, Cincinnati, OH 45244 (US).</b>			
(74) Agent: <b>CLARK, Paul, T.; Fish and Richardson, 225 Franklin Street, Boston, MA 02110 (US).</b>			

(54) Title: NEUROPEPTIDE Y ANTAGONISTS AND AGONISTS

(57) Abstract

The invention discloses analogs which behave as NPY antagonists and agonists; and methods of their use for controlling a biological activity such as appetite and cardiovascular function.

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NEUROPEPTIDE Y ANTAGONISTS AND AGONISTS

Background of the Invention

This invention relates to peptide derivatives which are antagonists or agonists of neuropeptide Y. Neuropeptide Y (NPY), is a 36-residue peptide characterized by a tyrosine (Y) residue at its N-terminus and a tyrosine amide residue at its C-terminus. The peptide was isolated from porcine brain (Tatemoto *Proc. Natl. Acad. Sci. U.S.A.* 79:5485-5489, 1982) and is considered to be a neurotransmitter or neuromodulator widely distributed in the central and peripheral nervous systems (Allen et al., *Neurochem. Int.* 8:1-8, 1986). It is the most abundant peptide present in the mammalian brain and heart (Edvinsson et al., *Trends Pharmol. Sci.* 8:231-235, 1987; Gu et al., *Histochem. Cytochem.* 32:467-472, 1984), and is among the most potent vasoconstrictor peptides isolated to date (Lundberg et al., *Acta Physiol. Scand.* 121:325-332, 1984). However, NPY elicits several physiological responses by activating specific pre- and post-synaptic receptors. Centrally, NPY is thought to be involved in the regulation of food intake, memory processing and circadian rhythm (Sheikh et al., *FEBS Lett.* 245: 209-214, 1989). In the periphery, NPY seems to function as a transmitter in sympathetic nerves where it interacts with norepinephrine mainly in the regulation of vasculartone (Sheikh et al. *FEBS Lett.* 245:209-214, 1989).

Different structure-activity relationships for NPY analogs in various model systems have indicated that multiple NPY receptor subtypes exist (Michel, *Tips* 12:389-394, 1991). Wahlestedt and coworkers (*Regul. Pept.* 13:307-318, 1986) first suggested the existence of two distinct subtypes of NPY receptors. Post-synaptic (Y1-type) effects could be obtained with the complete NPY

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molecule, while pre-synaptic (Y2-type) effects were found elicited by long C-terminal fragments, as well as with the entire NPY molecule. Thus, both Y1 and Y2 receptors exhibit nearly equal affinity to NPY and its homologous 5 peptide, peptide YY, but only the Y2 receptors could bind to shorter carboxyl-terminal fragments including NPY(13-36) as described by Sheikh et al. (FEBS Lett. 245:209-214, 1989). However, since NPY receptors in rat cardiac ventricular membranes discriminate between NPY and 10 peptide YY but bind NPY(13-36), it was suggested that this system be classified as a subtype of Y2 or a new class (designated Y3) of receptors as discussed below (Balasubramaniam et al. Peptides 11:545-550, 1990).

NPY is also present in high concentrations in a 15 distinct population of nerve fibers innervating the heart and blood vessels (Wharton et al., Ann. N.Y. Acad. Sci. 611:133-144, 1990). NPY is now regarded as the predominant peptide present in the cardiovascular system of mammals. This observation has led to numerous studies 20 of the cardiovascular properties of NPY. For example, several investigations have reported that NPY is a potent vasopressor peptide and that it inhibits the coronary blood flow and contractility in isolated perfused hearts (e.g., see Balasubramaniam et al., Regul. Pept. 21:289-259, 1988; Allen et al. Regul. Pept. 6:247-253, 1983; Rioux et al. Peptides 7:27-31, 1986). Furthermore, NPY is also capable of (1) inhibiting the contractile force 25 of isolated cardiac muscles (Balasubramaniam et al. *supra*) and myocytes (Piper et al. *Nuany-Schniedberg's* 30 *Arch. Pharmol.* 340: 333-337, 1989) and (2) the adenylate cyclase activity and cAMP production by cardiac muscles (Kassis et al., *J. Biol. Chem.* 262: 3429-3431, 1987) and myocytes (Kassis et al. *supra*; Millar et al. *Nuany-Schniedberg's Arch. Pharmol.* 338:426-429, 1989), 35 respectively. Specific receptors of NPY in rat cardiac

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ventricular membranes have been characterized and reported to be more selective to NPY than previously characterized NPY receptors as discussed above (Balasubramaniam et al. *Peptides* 11:545-550, 1990). The 5 presence of specific receptors of NPY in rat cardiac membranes, the Y-3 receptor, was also reported by visualization with  $N^a$  biotinyl-NPY analogs (Balasubramaniam et al. *Peptides* 11: 1151-1155, 1990).

The following table (the abbreviations used are 10 commonly known in the art and are described *infra*) shows the amino acid homology between NPY and PYY:

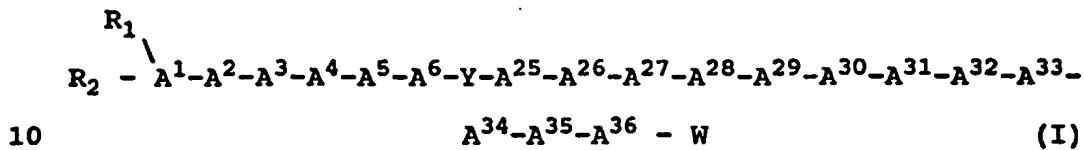
		5	10	15	20	25	30	35
		-----	-----	-----	-----	-----	-----	-----
	Human NPY	Y	P	S	K	D	N	P
15	Rat NPY	Y	P	S	K	D	N	P
	Rabbit NPY	Y	P	S	K	D	N	P
	Guinea pig NPY	Y	P	S	K	D	N	P
	Porcine NPY	Y	P	S	K	D	N	P
		Y	P	S	K	D	N	P
		I	E	A	P	G	E	D
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		E	A	P				

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### Summary of the Invention

In general, the invention features analogs which behave as NPY antagonists and agonists.

In one aspect, the present invention features 5 compounds having the formula:



wherein each

each  $R_1$  and  $R_2$ , independently, is H,  $C_1-C_{12}$  alkyl (e.g., methyl),  $C_6-C_{18}$  aryl (e.g., phenyl),  $C_1-C_{12}$  acyl (e.g., formyl, acetyl, and myristoyl),

15 C<sub>7</sub>-C<sub>18</sub> aralkyl (e.g., benzyl), or C<sub>7</sub>-C<sub>18</sub> alkaryl (e.g., *p*-methylphenyl);

$A^1$  is Tyr, or any aromatic amino acid;

$A^2$  is Pro, Hyp, D-Ala, N-Me-Ala, Ac<sub>c</sub>C, D-Pal or Asp;

$A^3$  is Ser, Thr, N-Me-Ser, N-Me-Thr, Ile, Val, Aib, Anb, Nle, or N-Me-Leu:

$A^4$  is the D- or L- isomer

consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

<sup>A5</sup> is Pro, Hyp, D-Ala, N-Me-Ala, Ac<sub>2</sub>G, D-Pal, or D-Txp;

$A^6$  is Gly or is the D- or L- isomer selected from the group consisting of Asp, Glu, N-Me-Asp, Ala, or Aoc:

30 Y is  $A^7 - A^8 - A^9 - A^{10} - A^{11} - A^{12} - A^{13} - A^{14} - A^{15} - A^{16} - A^{17} - A^{18} - A^{19} - A^{20} - A^{21} - A^{22} - A^{23} - A^{24}$  or is absent. where

$A^7$  is Asp, Ala, Gln, Gly, or N-Me-Asn:

$A^8$  is Pro, Ser, Thr, Hyp, D-Ala, N-Me-Ala, Ac<sub>6</sub>C, or D-Pal.

35  $A^9$  is Gly, N-Me-Gly, Ala or Trp:

$\text{A}^{10}$  is Glu, Asp, N-Me-Glu, Ala, or Nva.

$\text{A}^{11}$  is Asp, Glu, N-Me-Asp, Ala, or Asp;

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A<sup>12</sup> is Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;  
A<sup>13</sup> is Pro, Hyp, D-Ala, N-Me-Ala, Ac<sub>6</sub>C, D-Pal,  
Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal,  
Thi, Phe, Bth, Pcp, or N-Me-Ala;

5 A<sup>14</sup> is Ala, Pro, Hyp, D-Ala, N-Me-Ala, Ac<sub>6</sub>C, D-Pal  
Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

A<sup>15</sup> is Glu, Asp, N-Me-Glu, Ala, or Nva;

A<sup>16</sup> is Asp, Glu, N-Me-Asp, Ala, or Anb;

A<sup>17</sup> is Met, Leu, Ile, Val, Aib, Anb, Nle,  
10 or N-Me-Leu;

A<sup>18</sup> is Ala, Asn, Gln, Gly, N-Me-Asn, Nal, Thi,  
Phe, Bth, Pcp, or N-Me-Ala;

A<sup>19</sup> is the D- or L- isomer selected from the group  
15 consisting of Lys, Arg, homo-Arg, diethyl-  
homo-Arg, Lys-ε-NH-R (where R is H, a  
branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl  
group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

A<sup>20</sup> is Tyr, or any aromatic amino acid;

A<sup>21</sup> is Tyr, or any aromatic amino acid;

20 A<sup>22</sup> is Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal,  
Thi, Phe, Bth, Pcp, or N-Me-Ala;

A<sup>23</sup> is Ala, Ser, Thr, Nal, Thi, Phe, Bth, Pcp, N-  
Me-Ala, N-Me-Ser, or N-Me-Thr;

A<sup>24</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

25 A<sup>25</sup> is the D- or L- isomer selected from the group  
consisting of Lys, Arg, homo-Arg, diethyl-homo-  
Arg, Lys-ε-NH-R (where R is H, a branched or  
straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl  
group), or Orn;

30 A<sup>26</sup> is the D- or L- isomer selected from the group  
consisting of His, Thr, 3-Me-His, β-  
pyrazolylalanine, N-Me-His, Lys, Arg, homo-Arg,  
diethyl-homo-Arg, Lys-ε-NH-R (where R is H, a  
branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or  
a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

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A<sup>27</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid, Lys, or a tethered amino acid with an indole ring (e.g., Me-Trp);

5 A<sup>28</sup> is Aib or is the D- or L- isomer selected from the group consisting of Ile, Leu, Val, Anb, Trp, N-Me-Ile, or is deleted;

A<sup>29</sup> is Asn, Ala, Gln, Gly, N-Me-Asn or is deleted;

A<sup>30</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

10 A<sup>31</sup> is Ile, Cys, Leu, Val, Aib, Anb, or N-Me-Ile;

A<sup>32</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid except L-Tyr, a tethered amino acid with an indole ring (e.g., Me-Trp), Ant, Ser, N-Me-Ser, Thr, N-Me-Thr, 15 Ala, N-Me-Ala, D-Hyp, or any Trp derivative (e.g., 2-chlorotryptophan, or Tcc);

A<sup>33</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or 20 straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), Orn, or is deleted;

A<sup>34</sup> is Gln, Asn, N-Me-Gln, Nle, Nva, Ala, or Gly;

A<sup>35</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo- 25 Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

A<sup>36</sup> is Tyr, or any aromatic amino acid;

W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub>, 30 independently, is H, C<sub>1</sub>-C<sub>12</sub> alkyl (e.g., methyl), C<sub>6</sub>-C<sub>18</sub> aryl (e.g., phenyl), C<sub>1</sub>-C<sub>12</sub> acyl (e.g., formyl, acetyl, and myristoyl), C<sub>7</sub>-C<sub>18</sub> aralkyl (e.g., benzyl), or C<sub>7</sub>-C<sub>18</sub> alkaryl, (e.g., p-methylphenyl); wherein,

35 in formula (I) each bond can represent either a peptide

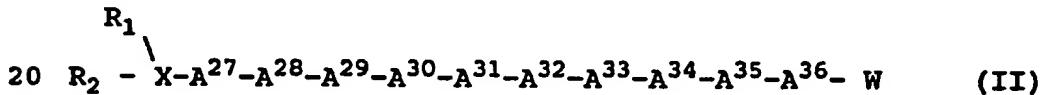
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bond or a pseudopeptide bond, provided that said compound cannot contain more than 3 pseudopeptide bonds, or a pharmaceutically acceptable salt thereof.

Preferably, said pseudopeptide bond is between 5 amino acid residues A<sup>29</sup>-A<sup>30</sup>, A<sup>34</sup>-A<sup>35</sup>, and A<sup>35</sup>-A<sup>36</sup>.

Preferred compounds formula (I) include those in which A<sup>32</sup> is D-Trp, D-Phe, D-Tyr, D-Bip, D-Dip, D-Bth, D-Nal, 2-Cl-Trp, Tcc, Trp, or a pharmaceutically acceptable salt thereof. In yet other preferred embodiments of the 10 invention the compounds of formula (I) include those in which Y (A<sup>7</sup>-A<sup>24</sup>) is deleted. Preferably, the compound of formula (I) is [D-Trp<sup>32</sup>]NPY, cyclo (2/27) Des-AA<sup>7</sup>-<sup>24</sup>[Asp<sup>2</sup>, D-Ala<sup>6</sup>, D-Lys<sup>27</sup>, D-Trp<sup>32</sup>]NPY, Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY, Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Gly<sup>6</sup>, D-Trp<sup>32</sup>]NPY or 15 Des-AA<sup>7-24</sup>[D-Trp<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY.

In another aspect, the invention features a compound having the formula:



wherein X is a chain of 0-7 amino acids, inclusive the N-terminal one of which is bonded to each R<sub>1</sub> and R<sub>2</sub>; wherein each R<sub>1</sub> and R<sub>2</sub>, independently, is

25 H, C<sub>1</sub>-C<sub>12</sub> alkyl (e.g., methyl), C<sub>6</sub>-C<sub>18</sub> aryl (e.g., phenyl), C<sub>1</sub>-C<sub>12</sub> acyl (e.g., formyl, acetyl, and myristoyl), C<sub>7</sub>-C<sub>18</sub> aralkyl (e.g., benzyl), or C<sub>7</sub>-C<sub>18</sub> alkaryl (e.g., p-methylphenyl);

30 A<sup>27</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid, Lys, or a tethered amino acid with an indole ring (e.g., Me-Trp);

A<sup>28</sup> is Aib or is the D- or L- isomer selected from the group consisting of Ile, Leu, Val, Anb, Trp,

35 N-Me-Ile, or is deleted;

A<sup>29</sup> is Asn, Ala, Gln, Gly, N-Me-Asn, or is deleted;

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$A^{30}$  is Leu, Ile, Val, Aib, Anb, or N-Me-Leu, or is deleted;

$A^{31}$  is Ile, Cys, D-Ala, Leu, Val, Aib, Anb, N-Me-Ile, or is deleted;

5  $A^{32}$  is the D- or L- isomer selected from the group consisting of any aromatic amino acid except L-Tyr, a tethered amino acid with an indole ring (e.g., Me-Trp), Ant, Ser, N-Me-Ser, Thr, N-Me-Thr, Ala, N-Me-Ala, D-Hyp, or any Trp derivative (e.g., 10 2-chlorotryptophan, or Tcc);

10  $A^{33}$  is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain  $C_1-C_{10}$  alkyl group, or a  $C_6-C_{18}$  aryl 15 group), Orn, or is deleted;

$A^{34}$  is Gln, Asn, N-Me-Gln, Nle, Nva, Ala, or Gly;

15  $A^{35}$  is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain  $C_1-C_{10}$  alkyl group, or a  $C_6-C_{18}$  aryl 20 group), or Orn;

$A^{36}$  is Tyr, or any aromatic amino acid;

W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where each R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub>, independently, is

25 H,  $C_1-C_{12}$  alkyl (e.g., methyl),  $C_6-C_{18}$  aryl (e.g., phenyl),  $C_1-C_{12}$  acyl (e.g., formyl, acetyl, and myristoyl),  $C_7-C_{18}$  aralkyl (e.g., benzyl), or  $C_7-C_{18}$  alkaryl (e.g., p-methylphenyl); wherein, in formula (II) each bond can represent either a peptide bond or a pseudopeptide bond, provided that said compound cannot contain more than 3 pseudopeptide bonds, or a pharmaceutically acceptable salt thereof.

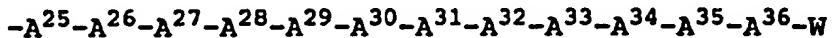
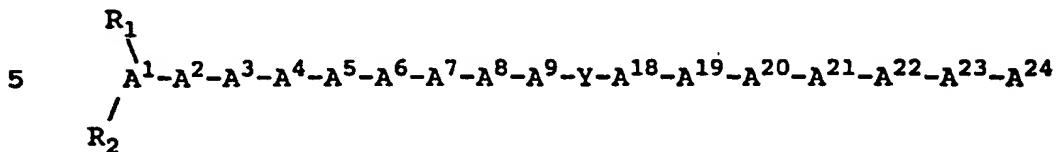
30 Preferred compounds of formula (II) include those where X is  $A^{20}-A^{21}-A^{22}-A^{23}-A^{24}-A^{25}-A^{26}$  where

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A<sup>20</sup> is Tyr, or any aromatic amino acid;  
A<sup>21</sup> is Tyr, or any aromatic amino acid;  
A<sup>22</sup> is Ser, Thr, N-Me-Ser, or N-Me-Thr;  
A<sup>23</sup> is Ala, Ser, Thr, Nal, Thi, Phe, Bth, Pcp, N-  
5 Me-Ala, N-Me-Ser, or N-Me-Thr;  
A<sup>24</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;  
A<sup>25</sup> is the D- or L- isomer selected from the group  
consisting of Lys, Arg, homo-Arg,  
diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is  
10 H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub>  
alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or  
Orn;  
A<sup>26</sup> is the D- or L- isomer selected from the group  
consisting of His, Thr, 3-Me-His,  $\beta$ -  
15 pyrazolylalanine, N-Me-His, Lys, Arg, homo-  
Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is  
H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl  
group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;  
W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where each R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub> ,  
20 independently, is  
H, C<sub>1</sub>-C<sub>12</sub> alkyl (e.g., methyl), C<sub>6</sub>-C<sub>18</sub> aryl  
(e.g., phenyl), C<sub>1</sub>-C<sub>12</sub>  
acyl (e.g., formyl, acetyl, and myristoyl),  
C<sub>7</sub>-C<sub>18</sub> alkaryl; or a pharmaceutically acceptable  
25 salt thereof.  
Preferably, said pseudopeptide bond is between  
amino acid residues A<sup>29</sup>-A<sup>30</sup>, A<sup>34</sup>-A<sup>35</sup>, and A<sup>35</sup>-A<sup>36</sup>.  
Preferably, the compound of formula (II) is [D-  
Trp<sup>28</sup>, D-Trp<sup>32</sup>]NPY (27-36), (Des-Asn<sup>29</sup>[D-Trp<sup>28</sup>, D-  
30 Trp<sup>32</sup>]NPY(27-36), Des-Asn<sup>29</sup>[D-Trp<sup>28</sup>, D-Trp<sup>32</sup>, Nva<sup>34</sup>]NPY(27-  
36), Des-Asn<sup>29</sup>[Trp<sup>28</sup>, Trp<sup>32</sup>, Nva<sup>34</sup>]NPY(27-36), and [D-  
Trp<sup>28</sup>, Ant<sup>32</sup>, Nva<sup>34</sup>]NPY(27-36), Des-Asn<sup>29</sup>[D-Trp<sup>28</sup>, Ant<sup>32</sup>,  
35 Nva<sup>34</sup>]NPY(27-36), or Des-Asn<sup>29</sup>, Arg<sup>33</sup>[D-Trp<sup>28</sup>, Ant<sup>32</sup>,  
Nva<sup>34</sup>]NPY(27-36).

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In another aspect the invention features a compound having a formula:



(III)

wherein a disulfide bond is between  $A^7$  and  $A^{21}$  or is absent; wherein each

15      each  $R_1$  and  $R_2$ , independently, is H,  $C_1-C_{12}$  alkyl (e.g., methyl),  $C_6-C_{18}$  aryl (e.g., phenyl),  $C_1-C_{12}$  acyl (e.g., formyl, acetyl, and myristoyl),  $C_7-C_{18}$  aralkyl (e.g., benzyl), or  $C_7-C_{18}$  alkaryl (e.g., *p*-methylphenyl);

20       $A^1$  is Tyr, or any aromatic amino acid;

25       $A^2$  is Pro, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , D-Pal or Asp;

30       $A^3$  is Ser, Thr, N-Me-Ser, N-Me-Thr, Ile, Val, Aib, Anb, Nle, or N-Me-Leu,

35       $A^4$  is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-

40      Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain  $C_1-C_{10}$  alkyl group, or a  $C_6-C_{18}$  aryl group), or Orn;

45       $A^5$  is Pro, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , D-Pal, or D-Trp;

50       $A^6$  is Gly or is the D- or L- isomer selected from the

55      group consisting of Asp, Glu, N-Me-Asp, Ala, or Aoc;

60       $A^7$  is Cys, Glu, Asn, Ala, Gln, Gly, or N-Me-Asn;

65       $A^8$  is Pro, Ser, Thr, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , or D-Pal;

70       $A^9$  is Gly, N-Me-Gly, Ala, or Trp;

75      Y is  $A^{10}-A^{11}-A^{12}-A^{13}-A^{14}-A^{15}-A^{16}-A^{17}$  or is absent, where

80       $A^{10}$  is Glu, Asp, N-Me-Glu, Ala, or Nva;

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branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

5 A<sup>27</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid, Lys, or a tethered amino acid with an indole ring (e.g., Me-Trp);

10 A<sup>28</sup> is Aib or is the D- or L- isomer selected from the group consisting of Ile, Leu, Val, Anb, Trp, N-Me-Ile, or is deleted;

15 A<sup>29</sup> is Asn, Ala, Gln, Gly, N-Me-Asn or is deleted; A<sup>30</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu; A<sup>31</sup> is Ile, Cys, Leu, Val, Aib, Anb, or N-Me-Ile; A<sup>32</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid except L-Tyr, a tethered amino acid with an indole ring (e.g., Me-Trp), Ant, Ser, N-Me-Ser, Thr, N-Me-Thr, Ala, N-Me-Ala, D-Hyp, or any Trp derivative (e.g., 2-chlorotryptophan, or Tcc);

20 A<sup>33</sup> is the D- or L- isomer is selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), Orn, is deleted;

25 A<sup>34</sup> is Gln, Asn, N-Me-Gln, Nle, Nva, Ala, or Gly; A<sup>35</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

30 A<sup>36</sup> is Tyr, or any aromatic amino acid; W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub>, independently, is H, C<sub>1</sub>-C<sub>12</sub> alkyl (e.g., methyl), C<sub>6</sub>-C<sub>18</sub> aryl (e.g., phenyl,), C<sub>1</sub>-C<sub>12</sub> acyl (e.g., formyl, acetyl, and myristoyl),

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5           C<sub>7</sub>-C<sub>18</sub> aralkyl (e.g., benzyl), or C<sub>7</sub>-C<sub>18</sub> alkaryl; wherein, in formula (III) each bond can represent either a peptide bond or a pseudopeptide bond, provided that said compound cannot contain more than 3 pseudopeptide bonds, or a pharmaceutically acceptable salt thereof.

Preferably, said pseudopeptide bond is between amino acid residues A<sup>29</sup>-A<sup>30</sup>, A<sup>34</sup>-A<sup>35</sup>, and A<sup>35</sup>-A<sup>36</sup>.

10           Preferably the compound of formula (III) is cyclo(7/21), Des AA<sup>10-17</sup>[Cys<sup>7</sup>, Cys<sup>21</sup>, D-Trp<sup>32</sup>]NPY, or cyclo(7/21), Des AA<sup>10-17</sup>[Glu<sup>7</sup>, Lys<sup>21</sup>, D-Trp<sup>32</sup>]NPY.

In another aspect, the invention features a compound with pseudopeptide bonds having the formula:

15           
$$\begin{array}{c} R_1 \\ | \\ R_2 - A^{18}-A^{19}-A^{20}-A^{21}-A^{22}-A^{23}-A^{24}-A^{25}-A^{26}-A^{27}-A^{28}-A^{29}-A^{30}-A^{31}- \\ \quad \quad \quad A^{32}-A^{33}-A^{34}-A^{35}-A^{36} - W \end{array} \quad (IV)$$

wherein each

20           each R<sub>1</sub> and R<sub>2</sub>, independently, is H, C<sub>1</sub>-C<sub>12</sub> alkyl (e.g., methyl), C<sub>6</sub>-C<sub>18</sub> aryl (e.g., phenyl), C<sub>1</sub>-C<sub>12</sub> acyl (e.g., formyl, acetyl, and myristoyl), C<sub>7</sub>-C<sub>18</sub> aralkyl (e.g., benzyl), or C<sub>7</sub>-C<sub>18</sub> alkaryl (e.g., p-methylphenyl);

25           A<sup>18</sup> is Ala, Asn, Gln, Gly, N-Me-Asn, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

A<sup>19</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys-ε-NH-R (where R is H, a branched or

30           straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

A<sup>20</sup> is Tyr, or any aromatic amino acid;

A<sup>21</sup> is Tyr, or any aromatic amino acid;

A<sup>22</sup> is Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala,

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A<sup>23</sup> is Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

A<sup>24</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

A<sup>25</sup> is the D- or L- isomer selected from the group  
5 consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

A<sup>26</sup> is the D- or L- isomer selected from the group  
10 consisting of His, Thr, 3-Me-His,  $\beta$ -pyrazolylalanine, N-Me-His, Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

15 A<sup>27</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid, Lys, or a tethered amino acid with an indole ring (e.g., Me-Trp);

A<sup>28</sup> is Aib or is the D- or L- isomer selected from the group consisting of Ile, Leu, Val, Anb, Trp, N-Me-Ile, or is deleted;

A<sup>29</sup> is Asn, Ala, Gln, Gly, N-Me-Asn, or is deleted;

A<sup>30</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

A<sup>31</sup> is Ile, Cys, Leu, Val, Aib, Anb, or N-Me-Ile;

25 A<sup>32</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid except L-Tyr, a tethered amino acid with an indole ring (e.g., Me-Trp), Ant, Ser, N-Me-Ser, Thr, N-Me-Thr, Ala, N-Me-Ala, D-Hyp, or any Trp derivative (e.g.,  
30 2-chlorotryptophan, or Tcc);

A<sup>33</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), Orn, or is deleted;

- 15 -

$A^{34}$  is Gln, Asn, N-Me-Gln, Nle, Nva, Ala, or Gly;  
 $A^{35}$  is the D- or L- isomer selected from the group  
consisting of Lys, Arg, homo-Arg, diethyl-homo-  
Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or  
straight chain  $C_1$ - $C_{10}$  alkyl group, or a  $C^6$ - $C_{18}$  aryl  
group), or Orn;  
 $A^{36}$  is Tyr, or any aromatic acid;  
W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where each R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub> ,  
independently, is  
H,  $C_1$ - $C_{12}$  alkyl (e.g., methyl),  $C_6$ - $C_{18}$  aryl (e.g.,  
phenyl),  $C_1$ - $C_{12}$  acyl (e.g., formyl, acetyl, and  
myristoyl),  $C_7$ - $C_{18}$  aralkyl (e.g., benzyl), or  $C_7$ -  
 $C_{18}$  alkaryl (e.g., *p*-methylphenyl);  
wherein, in formula (IV) each bond can represent either a  
peptide or a pseudopeptide bond, provided that said  
compound cannot contain more than 3 pseudopeptide bonds,  
or a pharmaceutically acceptable salt thereof. In  
preferred embodiments, the compound contains a  
pseudopeptide bond between  $A^{30}$  and  $A^{31}$ ;  $A^{31}$  and  $A^{32}$ ; or  $A^{32}$   
and  $A^{33}$ .

In another aspect, the invention features a method of suppressing an NPY mediated physiological response in a tissue other than the heart in a subject comprising administering to said subject a compound having the following formula:

8

$R_2 - A^{18} - A^{19} - A^{20} - A^{21} - A^{22} - A^{23} - A^{24} - A^{25} - A^{26} - A^{27} - A^{28} - A^{29} - A^{30} - A^{31} -$

30  $A^{32}-A^{33}-A^{34}-A^{35}-A^{36} - W$

wherein each  
each  $R_1$  and  $R_2$ , independently, is H,  $C_1-C_{12}$  alkyl (e.g.,  
methyl),  $C_6-C_{18}$  aryl (e.g., phenyl),  $C_1-C_{12}$   
acyl (e.g., formyl, acetyl, and myristoyl),  
 $C_7-C_{18}$  aralkyl (e.g., benzyl), or  $C_7-C_{18}$  alkaryl

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(e.g., *p*-methylphenyl);  
A<sup>18</sup> is Ala, Asn, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;  
A<sup>19</sup> is the D- or L- isomer selected from the group  
consisting of Lys, Arg, homo-Arg, diethyl-homo-  
5 Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or  
straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl  
group), or Orn;  
A<sup>20</sup> is Tyr, or any aromatic amino acid;  
A<sup>21</sup> is Tyr, or any aromatic amino acid;  
10 A<sup>22</sup> is Ser, Thr, N-Me-Ser, or N-Me-Thr;  
A<sup>23</sup> is Ala, Ser, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;  
A<sup>24</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;  
A<sup>25</sup> is the D- or L- isomer selected from the group  
consisting of Lys, Arg, D-homo-Arg, D-diethyl-  
15 homo-Arg, D-Lys- $\epsilon$ -NH-R (where R is H, a branched  
or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub>  
aryl group), or Orn;  
A<sup>26</sup> is the D- or L- isomer selected from the group  
consisting of His, Thr, 3-Me-His,  $\beta$ -  
20 pyrazolylalanine, N-Me-His, Lys, Arg, homo-Arg,  
diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a  
branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or  
a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;  
A<sup>27</sup> is the D- or L- isomer selected from the group  
25 consisting of any aromatic amino acid, Lys, or a  
tethered amino acid with an indole ring (e.g., Me-  
Trp);  
A<sup>28</sup> is Aib or is the D- or L- isomer selected from the  
group consisting of Ile, Leu, Val, Anb, Trp,  
30 N-Me-Ile, or is deleted;  
A<sup>29</sup> is Asn, Ala, Gln, Gly, N-Me-Asn, or is deleted;  
A<sup>30</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;  
A<sup>31</sup> is Ile, Cys, Leu, Val, Aib, Anb, or N-Me-Ile;  
A<sup>32</sup> is the D- or L- isomer selected from the group  
35 consisting of any aromatic amino acid except L-

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Tyr, a tethered amino acid with an indole ring (e.g., Me-Trp), Ant, Ser, N-Me-Ser, Thr, N-Me-Thr, Ala, N-Me-Ala, D-Hyp, or any Trp derivative (e.g., 2-chlorotryptophan, or Tcc);

5 A<sup>33</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), Orn, or is deleted;

10 A<sup>34</sup> is Gln, Asn, N-Me-Gln, Nle, Nva, Ala, or Gly;

A<sup>35</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

15 A<sup>36</sup> is Tyr, or any aromatic acid;

W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where each R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub>,

independently, is

20 H, C<sub>1</sub>-C<sub>12</sub> alkyl (e.g., methyl), C<sub>6</sub>-C<sub>18</sub> aryl (e.g., phenyl), C<sub>1</sub>-C<sub>12</sub> acyl (e.g., formyl, acetyl, and myristoyl), C<sub>7</sub>-C<sub>18</sub> aralkyl (e.g., benzyl), or C<sub>7</sub>-C<sub>18</sub> alkaryl (e.g., p-methylphenyl); wherein, each bond can represent either a peptide bond or a pseudopeptide bond, provided that said compound

25 cannot contain more than 3 pseudopeptide bonds, or a pharmaceutically acceptable salt thereof.

Preferably, said pseudopeptide bond is between amino acid residues A<sup>29</sup>-A<sup>30</sup>, A<sup>34</sup>-A<sup>35</sup>, and A<sup>35</sup>-A<sup>36</sup>. or a pharmaceutically acceptable salt thereof.

30 In preferred embodiments, the method suppresses the activity of the NPY (Y-1) receptor or the NPY (Y-2) receptor.

In another aspect, the invention features a method of suppressing a NPY(Y-1) receptor mediated physiological

35 response in the hypothalamus of a subject comprising

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administering to said subject the compound of formula (I).

In another aspect, the invention features a method of suppressing the blood pressure of a subject 5 experiencing hypertension which comprises administering to said subject the compound of formula (I).

In another aspect, the invention features a method of suppressing a NPY(Y-3) receptor mediated physiological response in the cardiovascular system of a subject 10 comprising administering to said subject the compound of formula (IV).

In other preferred embodiments, a therapeutically effective amount of a compound of formula (I), (II), (III) or (IV) and a pharmaceutically 15 acceptable carrier substance, e.g., magnesium carbonate or lactose, together form a therapeutic composition capable of suppressing an NPY mediated physiological response. This composition can be in the form a pill, tablet, capsule, liquid, or sustained released tablet for 20 oral administration; or a liquid for nasal administration as drops or spray; or a liquid for intravenous, subcutaneous, parenteral, or intraperitoneal administration.

Another preferred form for administration 25 biodegradable sustained-release composition for intramuscular administration to a subject in need of the composition. Preferably, the composition includes a lipophilic salt and is suitable for administration in the form of an oil emulsion or dispersion to a subject in 30 need of the composition.

In yet another aspect, the invention features methods for suppressing an NPY mediated physiological response in a subject; such methods involve administering one or more of the above mentioned compounds to a subject 35 in a dosage effective to lower blood pressure; to

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suppress the appetite; to augment the libido; to stimulate cardiovascular function; or to modulate the circadian rhythm.

In still another aspect, the invention features 5 methods for stimulating an NPY mediated physiological response in a subject; such methods involve administering one or more of the above mentioned compounds to a subject in a dosage effective to increase blood pressure; to increase the appetite; to augment the libido; or to 10 stimulate cardiovascular function.

The symbol  $A^1$ ,  $A^2$ ,  $A^3$ , and the like; and Tyr, Lys or the like, as found in a peptide sequence herein stands for an amino acid residue, e.g.,  $=N-CH(R)-CO-$  when it is at the N-terminus, or  $-NH-CH(R)-CO-$  when it is at any 15 other position, where R denotes the side chain (or identifying group) of an amino acid or its residue. For example, R is  $-CH_2COOH$  for Asp, R is  $-H$  for Gly, R is  $-CH_2OH$  for Ser, R is  $-CH_3$  for Ala and R is  $-CH_2CH_2CH_2CH_2NH_2$  for Arg. Also, when the amino acid residue is optically 20 active, it is the L-form configuration that is intended unless the D-form is expressly designated. By pseudopeptide bond is meant that the carbon atom participating in the bond between two residues is reduced from a carbonyl carbon to a methylene carbon, i.e.,  $CH_2-$  25 NH; or less preferably that of C)-NH is replaced with any of  $CH_2-S$ ,  $CH_2-O$ ,  $CH_2-CH_2$ ,  $CH_2-CO$ , or  $CH_2-CH_2$ . (A pseudopeptide peptide bond is symbolized herein by or "ψ".) A detailed discussion of the chemistry of pseudopeptide bonds is given in Coy et al. (1988) 30 Tetrahedron 44:835-841.

In other embodiments, the compounds of Formulae (I), (II), (III), or (IV) are cyclic. Preferably, the cyclization is formed by a disulfide or lactam bridge (amide bond). In this disclosure, the disulfide or amide 35 bond which links two residues in a compound of the

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invention are formed between the side chain functionalities. That is, between the side-chain carboxyl group of an acidic amino acid residue (e.g., Asp or Glu) and the side chain amino group of a basic amino acid residue (e.g., Lys or Orn), or between the side chain sulfhydryl groups of two Cys. In all formulae set forth herein, the amide or disulfide bond between two residues are not shown. A compound of this invention is also denoted by another format, e.g. cyclo (2/27) Des-  
5 AA<sup>7-24</sup>[Asp<sup>2</sup>, D-Ala<sup>6</sup>, D-Lys<sup>27</sup>, D-Trp<sup>32</sup>] NPY and cyclo(7/21) Des AA<sup>10-17</sup>[Cys<sup>7</sup>, Cys<sup>21</sup>, D-Trp<sup>32</sup>]NPY.  
10 AA<sup>10-17</sup>[Cys<sup>7</sup>, Cys<sup>21</sup>, D-Trp<sup>32</sup>]NPY.

Preferred cyclic compounds of the invention are cyclo (2/27) Des AA<sup>7-24</sup>[Asp<sup>2</sup>, D-Ala<sup>6</sup>, D-Lys<sup>27</sup>, D-Trp<sup>32</sup>] NPY and cyclo(7/21) Des AA<sup>10-17</sup>[Cys<sup>7</sup>, Cys<sup>21</sup>, D-Trp<sup>32</sup>]NPY.

15 In another aspect, the invention features novel dimeric analogs of NPY. The dimer may be formed by either including one compound of Formula I, II, III, or IV and one compound of Formula I, II, III, or IV. In one embodiment, the dimer is formed by utilizing a  
20 dicarboxylic acid linker capable of binding to a free amine, either primary or secondary, located within each compound. See R. Vavrek and J. Stewart, Peptides: Structure and Function 381-384 (Pierce Chemical Co. 1983). Examples of suitable dicarboxylic acid linkers  
25 are succinic acid, glutamic acid, and phthalic acid. In other embodiments, the dimer is formed by utilizing an amino acid linker capable of binding to a free amine group of one compound and a free carboxylic acid group of the other compound. Preferably, the amino acid linker is  
30 a non- $\alpha$ -amino acid. Examples of suitable amino acid linkers are amino-caproic acid and amino-valeric acid. In yet another embodiment, the dimer is formed by disulfide bridge between cysteines located within each compound. See M. Berngtowicz and G. Piatsueda, Peptides:  
35 Structure and Function 233-244 (Pierce Chemical Co.

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1985); F. Albericio, et al., Peptides 1990 535 (ESCOM  
1991).

Preferred dimeric compounds of the invention are  
Bis(31/31) [Cys<sup>31</sup>, Trp<sup>32</sup>, Nva<sup>34</sup>]NPY(27-36), and Bis(31/31)  
5 (Cys<sup>31</sup>, Trp<sup>32</sup>, Nva<sup>34</sup>]NPY(31-36),

As set forth above and for convenience in  
describing this invention, the conventional and  
nonconventional abbreviations for the various amino acids  
are used. They are familiar to those skilled in the art;  
10 but for clarity are listed below. All peptide sequences  
mentioned herein are written according to the usual  
convention whereby the N-terminal amino acid is on the  
left and the C-terminal amino acid is on the right. A  
short line between two amino acid residues indicates a  
15 peptide bond.

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Abbreviations (common):

Asp = D = Aspartic Acid  
Ala = A = Alanine  
20 Arg = R = Arginine  
Asn = N = Asparagine  
Cys = C = Cysteine  
Gly = G = Glycine  
Glu = E = Glutamic Acid  
25 Gln = Q = Glutamine  
His = H = Histidine  
Ile = I = Isoleucine  
Leu = L = Leucine  
Lys = K = Lysine  
30 Met = M = Methionine  
Phe = F = Phenylalanine  
Pro = P = Proline  
Ser = S = Serine  
Thr = T = Threonine

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Trp = W = Tryptophan

Tyr = Y = Tyrosine

Val = V = Valine

**Abbreviations (uncommon):**

5 Aoc = (8-aminooctanoic acid:

Orn = Ornithine

Nal = 2-naphthylalanine

Thi = 2-thienylalanine

Pcp = 4-chlorophenylalanine

10 Bth = 3-benzothienylalanine

Bip = 4,4'-biphenylalanine

Tic = tetrahydroisoquinoline-3-carboxylic acid

Aib = aminoisobutyric acid

Anb =  $\alpha$ -aminonormalbutyric acid

15 Dip = 2,2-diphenylalanine

Ac<sub>6</sub>C = 1-aminocyclohexanecarboxylic acid

D-Pal =  $\beta$ -(3-pyridyl)alanine;

Tcc = tetrahydrocarbolinenecarboxylic acid

Nva = norvaline

20 Ant = anthranilic acid

Hyp = hydroxyproline

Nle = norleucine

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The compounds of the invention are useful for  
25 reducing, suppressing or mitigating the effects of NPY.

For example, the compounds of the invention are  
especially useful in treating any number of illnesses  
that involve eating disorders, cardiovascular function,  
alterations in sexual function, as well as disorders of  
30 sleep and circadian rhythms (see, e.g., *Harrison's  
Principles of Internal Medicine*, McGraw-Hill Inc., New  
York, 12th ed.). Specific examples of such disorders,  
include without limitation, obesity, anorexia,  
hypertension, hypotension, congestive heart failure,

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impotence, dyssomnias and rapid time-zone change syndrome. Strategic design of the NPY antagonists, as described herein, allows for the selective antagonism of different classes of NPY receptors, e.g., Y3 cardiac receptors, without adverse interaction with other NPY receptors. The compounds are also useful for stimulating NPY receptor mediated events, e.g., increasing the blood pressure of a subject.

Other features and advantages of the invention will be apparent from the following description of the preferred embodiments thereof, and from the claims.

#### Description of Preferred Embodiments

The drawings will first be described.

#### DRAWINGS

Fig. 1 shows the comparison of the effects of D-Trp or D-Trp(CHO) substituted NPY analogs (1.0  $\mu$ M) on the isoproterenol stimulated adenylate cyclase activity of rat hypothalamic membranes. Iso, isoproterenol. I., [D-Trp<sup>32</sup>]Trp<sup>32</sup>]NPY; II, [D-Trp(CHO)<sup>32</sup>]NPY; III, [D-Trp<sup>34</sup>]NPY; IV, [D-Trp(CHO)<sup>34</sup>]NPY; V, [D-Trp<sup>36</sup>]NPY; VI, [D-Trp(CHO)<sup>36</sup>]NPY; a=p,0.01 compared to isoproterenol; b, not significant compared to isoproterenol.

Fig. 2 shows the displacement of <sup>125</sup>I-NPY bound to rat hypothalamic membranes by increasing concentrations NPY (•) and [D-Trp<sup>32</sup>] NPY (□).

Fig. 3 shows the dose-response effects of increasing concentrations of [D-Trp<sup>32</sup>] NPY (□), NPY alone (•); NPY in the presence of 30 (▲) and 300 (■) nM doses of [D-Trp<sup>32</sup>] NPY on the isoproterenol stimulated adenylate cyclase activity of rat hypothalamic membranes.

Fig. 4 shows the comparison of the effects of [D-Trp<sup>32</sup>]NPY (1.0  $\mu$ M) on the inhibition of isoproterenol stimulated adenylate cyclase activity of rat hypothalamic membranes by NPY (100 nM) and serotonin (100 nM). a = p <

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0.01 compared to isoproterenol; b, not significant compared to isoproterenol .

Fig. 5 shows the antagonism of NPY induced feeding in rats by [D-Trp<sup>32</sup>]NPY.

5 Fig. 6 shows the effects of 1  $\mu$ M doses of NPY and its analogs [L-Trp<sup>32</sup>] NPY, [D-Trp<sup>32</sup>(CHO)] NPY, [D-Nal<sup>32</sup>] NPY, [D-Hyp<sup>32</sup>] NPY, [(3-1-Tyr<sup>27</sup>), D-Trp<sup>32</sup>] NPY, and [(3-1-Tyr<sup>27,36</sup>), D-Trp<sup>32</sup>] NPY on isoproterenol stimulated adenylate cyclase activity of rat hypothalamic membranes.

10 (iso = isoproterenol); (a = p < 0.005 vs. iso.); (n.s. = not significant).

15 Fig. 7 shows the effects of increasing concentrations of NPY in the absence (0) and presence (•) of Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>] NPY (1  $\mu$ M) on the isoproterenol stimulated cAMP production by SK-N-MC cells. Also shown is the effect of increasing concentrations of Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY (□) on the isoproterenol stimulated cAMP production by SK-N-MC cells.

20 Fig. 8 shows the effects of increasing concentrations of NPY on the blood pressure of anesthetized rats in the absence (0) and presence (•) of 200 nmol/kg of Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY.

25 Fig. 9 shows the effects of increasing concentrations of NPY (0) and NPY (18-36) (Δ) on the binding of <sup>125</sup>I-NPY to SK-N-BE2 cells.

30 Fig. 10 shows the effects of NPY (0), NPY (18-36) (Δ) and NPY in the presence of 1 $\mu$ M dose of NPY (18-36) (•) on forskolin stimulated cAMP production by SK-N-BE2 cells.

35 Figs. 11A-11C show the analytical RPLC of [ $\Psi^{30-31}$ ] NPY (18-36) (11A), [ $\Psi^{32-33}$ ] NPY (18-36) (11B), and [ $\Psi^{33-34}$ ] NPY (18-36) (11C).

Fig. 12 shows the inhibition of <sup>125</sup>I-NPY binding 35 to rat cardiac ventricular membrane by NPY (0), NPY

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(18-36) (■), [ $\Psi^{30/31}$ ] NPY (18-36) (△), [ $\Psi^{31/32}$ ] NPY (18-36) (▲), and [ $\Psi^{32/33}$ ] NPY (18-36) (□).

Any number of analogs of the invention can be synthesized and tested in one or more of the assays are 5 described below or by methods which are known in the art. We now describe preferred embodiments of the invention.

STRUCTURE

The sequences of naturally occurring NPY are described *supra*. As is easily observed, there is a high 10 degree of amino acid homology between NPY and PYY.

The analogs of the invention have the general formula recited in the Summary of the Invention above. The analogs of the invention are based upon the biologically active full-length molecule (amino acids 1-15 36) comprising amino acids of NPY and PYY and derivatives thereof; and upon the biologically active subfragments comprising amino acids of NPY and PYY and derivatives thereof.

The analogs of the invention may have one or more 20 modifications to the NPY and PYY sequences (see above). For example, the compounds may have one or more of the following modifications which are useful for obtaining selective activity at a NPY receptor: a D-Trp or Aoc or D-Ala in place of one or two or three natural amino acids; or a deletion of several N-terminal amino acids; or the introduction of a pseudopeptide bond instead of a peptide bond between two adjacent amino acids. The 25 analog is capable of acting as a competitive inhibitor of the naturally occurring NPY peptide by binding to the receptor and, by virtue of one of the modifications described *supra* herein, fail to exhibit the biological activity of the naturally occurring peptide. For example, the peptides for which introduction of a pseudopeptide bond between two residues, or the 30 replacement of one or more natural amino acids with a D-

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Trp, or the deletion ("des") of the N-terminal residues or internal residues are useful in activity associated NPY activity.

The analogs of the invention can be provided in 5 the form of pharmaceutically acceptable salts. Examples of preferred salts are those with therapeutically acceptable organic acids, e.g., acetic, lactic, maleic, citric, malic, ascorbic, succinic, benzoic, or pamoic acid, as well as polymeric acids and salts with 10 inorganic acids such as the hydrohalic acids, e.g., hydrochloric and sulfuric acids.

#### SYNTHESIS

##### Peptide Synthesis

The compounds of the present invention, i.e., 15 compounds of formulas (I), (II), (III), (IV), and (V) may be synthesized by any techniques that are known to those skilled in the peptide art. Such techniques are described in, e.g., *Solid Phase Peptide Synthesis*, eds, John M. Stewart and Janis D. Young, Pierce Chemical 20 Company, Rockford, IL, 2nd edition.

The syntheses of the peptides listed in Table 1 and Table 2 were carried out as follows. Peptides were synthesized in an Applied Biosystems model 430A automated instrument, cleaved by hydrogen fluoride, and purified by 25 reversed phase chromatography as described by Balasubramaniam et al. (*Int. J. Pept. Protein Res.* 29:78-83, 1987; *Pept. Res.* 1:32-35, 1988). All synthetic peptides were >98% pure as determined by reverse phase chromatography and had the expected amino acid 30 composition and primary structure. Other analogs can be prepared by making appropriate modifications, within the ability of someone of ordinary skill in this field.

In addition, pseudopeptide bonds may, if desired, may be introduced at various positions, e.g., between 35 amino acid residues 31-32 of NPY(18-36) or between

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residues 32-33 of NPY(18-36), or of any peptide as described below. Despite the fact that optically pure Boc-AA-CHO can be obtained in good yields and coupled directly to the  $\alpha$ -NH<sub>2</sub> group of the peptide resin by 5 published methods (Sasaki et al., *Peptides* 8:119-121, 1987; Fehrentz et al., *Synthesis* pp.676-678, 1983), this strategy has its limitations because of the possibility of branching at the secondary amine group especially during the synthesis of long peptides with pseudobonds at 10 the C-terminal region. Therefore the utility of several protecting groups, Z, Tos and Z(2-Cl), for capping the secondary amine group in the peptide resin was investigated. Although the reaction of the peptide resin with Z-Cl/Tos-Cl (2 equiv.) & DIEA (4 equiv.) completely 15 blocked the secondary amine, the known lability of Z- during repeated acidolysis to remove Boc group and the apparent resistance of Tos group to HF led us to choose Z(2-Cl) the secondary amine for capping. This is introduced by reacting the peptide resin with Z(2-Cl)-OSU 20 (2 equiv.), HOBT (2 equiv.) and DIEA (4 equiv.) for 10-60 min. The red wine color of ninhydrin with secondary amine turned yellow at the end of capping. This method yielded [ $\Psi^{30/31}$ ]NPY(18-36), [ $\Psi^{31/32}$ ]NPY(18-36) [ $\Psi^{32/33}$ ]NPY(18-36) in greater than 65% yield as judged by 25 analytical HPLC. These peptides not only retained the antagonistic effect, but also exhibited increased affinity (20-220 times) and selectivity for cardiac NPY receptors than NPY(18-36) as discussed below. Integrity of peptides containing pseudobonds were confirmed by mass 30 spectral analysis. Pseudopeptide bond-containing analogs of NPY synthesized by these methods are listed in Table II. Protected amino acid derivatives (Peptide International, Louisville, KY) and peptide synthesis reagents (Applied Biosystems, Foster City, CA) were

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obtained commercially and used without further purification.

Examples of the synthesized analogs are:

Formula (I) Compounds

5	D-Trp <sup>32</sup> ]NPY	YPSKPDNPGE[D- D-Nal <sup>32</sup> ]NPY	YPSKPDNPGE[D-Nal]RQRY-NH <sub>2</sub>
	D-Phe <sup>32</sup> ]NPY	YPSKPDNPGE[D-Phe]RQRY-NH <sub>2</sub>	
	D-Hyp <sup>32</sup> ]NPY	YPSKPDNPGE[D-Hyp]RQRY-NH <sub>2</sub>	
	[L-Trp <sup>32</sup> ]NPY	YPSKPDNPGE[L-Trp]RQRY-NH <sub>2</sub>	

10 Des AA<sup>7-24</sup>[D-Trp<sup>32</sup>]NPY

YPSKPD-----RHYINLI[D-Trp]RQRY-NH<sub>2</sub>

Des AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY

YPSK[D-Ala][Aoc]-----RHYINLI[D-Trp]RQRY-NH<sub>2</sub>

Des AA<sup>7-24</sup>[Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY

15 YPSKP[Aoc]-----RHYINLI[D-Trp]RQRY-NH<sub>2</sub>

Formula (II) Compounds

D-Ala<sup>28</sup>, D-Trp<sup>32</sup>]NPY(27-36) Y[D-Ala]NLID-Trp]RQRY-NH<sub>2</sub>

Des-Asn<sup>29</sup>[D-Trp<sup>28,32</sup>]NPY(27-36) Y[D-Trp]-LI[D-Trp]RQRY-NH<sub>2</sub>

Formula (III) Compounds

20 cyclo(7/21), Des AA<sup>10-17</sup>[Cys<sup>7</sup>, Cys<sup>21</sup>, D-Trp<sup>32</sup>]NPY

YPSKPD<sup>PG</sup>-----ARYCSALRHYINLI[D-Trp]RQRY-NH<sub>2</sub>

cyclo(7/21), Des AA<sup>10-17</sup>[Glu<sup>7</sup>, Lys<sup>21</sup>, D-Trp<sup>32</sup>]NPY

YPSKPD<sup>PG</sup>-----ARYKSALRHYINLI[D-Trp]RQRY-NH<sub>2</sub>

Formula (IV) Compounds

25	[ 30/31]NPY (18-36)	-----ARYYSALRHYINLITRQRY-NH <sub>2</sub>
	[ 31/32]NPY (18-36)	-----ARYYSALRHYINLITRQRY-NH <sub>2</sub>
	[ 32/33]NPY (18-36)	-----ARYYSALRHYINLITRQRY-NH <sub>2</sub>

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Other analogs of the invention can be prepared as above and tested for their biological activity effectiveness as antagonists or agonists using the methods described below and those commonly known in the art.

#### FUNCTIONAL ASSAYS

##### Animals, Cell Lines and Cultures, and Reagents

Any suitable in vivo or in vitro system may be utilized to assay and test the effectiveness of the compounds of the invention. Such assays may employ in vivo methods for evaluating physiological responses, e.g., blood pressure, renovascular function, feeding behavior, or circadian rhythm, or in vivo biochemical systems evaluating receptor binding in a suitable cell line, e.g., SK-N-MC (ATCC#HBT 10) or SK-N-BE(2) (Barnes et al. *In Vitro* 17: 619-631, 1981); or in isolated cells, e.g., cells isolated from the spleen, kidney, heart or brain. A number of in vivo and in vitro biochemical systems known to those skilled in the art are available for testing antagonists to NPY receptors, e.g. the Y-1, Y-2, and Y-3 receptor categories. Described below are assay methods which can be utilized with cell lines such as SK-N-MC and SK-N-BE2 or isolated cardiac membranes which possess the high-affinity NPY receptor sites Y-1, Y-2, and Y-3, respectively. Other systems are also known for evaluating NPY antagonists to the Y-1 receptor, e.g. VSM cells (Sheikh et al., *Am. J. Physiol.* 260: G250-G257, 1991) and HEL cells (Motulsky et al. *Amer. J. Physiol.* 255: E880-E885, 1988); Y-2 receptor, e.g., kidney (Sheikh et al., *Am. J. Physiol.* 26: F978-F984), spleen (Lunberg et al., *Eur. J. Pharmal.* 145:21-29, 1988), dorsal root ganglion (Bleakman et al., *Br. J. Pharmal.* 103:1781-1789, 1991) and hippocampal cells (Sheikh et al., *J. Biol. Chem.* 265:8304-8310, 1990); and Y-3 receptors, e.g., in cardiac ventricular membranes (Balasubramaniam et al.,

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Peptides 11: 545-550, 1990), chromaffin cells, rat  
gastric mucosa (Michel, M.C., *Trends in Pharmol. Sci.* 12:  
389-394, 1991) and brain stem.

In Vitro Biochemical Assays

5 The ability of the compounds of the invention to act as antagonists of NPY can be demonstrated by any number of methods known in the art. For example, the compounds can be shown to compete with iodinated neuropeptide Y for receptors using the methods described

10 by Lundberg et al. (*Eur. J. Pharmol.* 145: 21-29, 1988); Gordon et al. (*J. Neurochemistry* 55:506-513, 1990); Walker et al. (*Mol. Pharmacol.* 34:779-792, 1988); Balasubramaniam et al. (*Peptides* 10:1283-1286, 1989), and others.

15 In one working example demonstrating antagonists to Y-1 receptors, rat hypothalamus was isolated and the membranes were prepared for binding and adenylylate cyclase studies according to standard methods (Unden et al. 1984. *Eur. J. Biochem* 145: 525-530; Westlind-Danielsson et al.

20 1987. *Neurosci. Lett.* 74: 237-242). Displacement studies were performed in a total volume of 0.25 ml 20 mM HEPES buffer, pH 7.4, containing 1% bovine serum albumin, 0.1% bacitracin, 300  $\mu$ M PMSF and 5 KIU/ml aprotinin. In a standard assay, 100  $\mu$ g of membrane/tube was incubated in

25 a shaking water bath at 24° C for 45 min with [ $^{125}$ I-Tyr<sup>1</sup>]-NPY (20,000 CPM) as described by Balasubramaniam et al (*Peptides* 11: 545-550, 1990) in the presence of increasing concentrations of NPY ( $10^{-11}$ - $10^{-5}$  M). At the end of incubation, 1.0 ml of iced cold buffer was added,

30 centrifuged at 10,000 X g for 10 min, and the supernatant removed by aspiration. The tube containing the pellet was counted for bound radioactivity in a micromedic gamma-counter.

An example of assaying adenylylate cyclase activity  
35 of hypothalamic and cerebral cortex membranes is now

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described. Adenylate cyclase activity of the hypothalamic and cerebral cortex membranes was determined by incubating 50  $\mu$ g of membranes in a total volume of 0.20 ml Tris-HCL 30 mM pH 7.4 buffer containing 150 mM 5 NaCl, 8.25 mM MgCl<sub>2</sub>, 0.75 mM EGTA, 1.5 theophylline, 20  $\mu$ g/ml aprotinin, 100  $\mu$ g/ml bacitracin, 1 mg/ml bovine serum albumin, 1 mM ATP, 20 mM creatine phosphate, 1 mg/ml phosphocreatine kinase, 10  $\mu$ M isoproterenol, 10  $\mu$ M GTP, and various concentrations of peptides (0-10  $\mu$ M).  
10 After incubating the mixture at 35° C for 15 min in a shaking water bath, the reaction was arrested by the addition of 100  $\mu$ M EDTA and boiling for 3 min. cAMP was extracted and quantitated by radioimmunoassay. All the points in the binding and adenylate cyclase are the means  
15 of at least three parallel experiments performed in duplicate.

In one working example demonstrating antagonists to Y-3 receptors, rat cardiac ventricular membranes and iodination of NPY were prepared according to the method 20 described by Balasubramaniam et al. (Peptides 11: 545-550, 1990). Displacement studies were performed in a total volume of 0.25 ml of 20 mM HEPES assay buffer, pH 7.6, containing 2% bovine serum albumin, 100  $\mu$ M phenylmethylsulfonyl fluoride, 4  $\mu$ g/ml leupeptin, 4  $\mu$ g/ml 25 chymostatin, 5 kallikrein-inactivating units/ml aprotinin, and 0.1% bacitracin. In a standard assay, 200  $\mu$ g of membrane protein/tube were incubated for 2 h at 18° C in a shaking water bath with <sup>125</sup>I-NPY (40 pM) and increasing concentrations of peptides. At the end of 30 incubation, tubes were vortexed and 150  $\mu$ l aliquots transferred into polypropylene tubes containing 250  $\mu$ l of ice-cold assay buffer. Unbound <sup>125</sup>I-NPY was separated by centrifugation at 10,000 x g for 10 min followed by aspiration of the supernatant. The tubes containing the 35 pellet were counted for bound radioactivity in a

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Micromedic  $\gamma$  counter. The  $IC_{50}$  values were used to calculate the equilibrium dissociation constant,  $K_i$  for NPY and NPY antagonists using the equation  $K_i = IC_{50}/(1 + F/K_d)$ , where  $F$  and  $K_i$  denote the concentration and the 5 dissociation constant of  $^{125}I$ -NPY.

Adenylate cyclase activity was measured by Rosselin et al. (*Biochim. Biophys. Acta* 304:541-551, 1977). Each experiment was carried out in a total volume of 200  $\mu$ l solution containing 30 mM Tris-HCl, pH 7.4, 150 10 mM NaCl, 8.25 mM MgCl<sub>2</sub>, 0.75 mM EGTA, 1.5 mM theophylline, 20  $\mu$ g/ml aprotinin, 100  $\mu$ g/ml bacitracin, 1 mg/ml BSA, 1 mM ATP, 20 mM creatine phosphate, 1 mg/ml phosphocreatine kinase, 10  $\mu$ M isoproterenol, 10  $\mu$ M GTP, and various concentrations of peptides (0-10  $\mu$ M). The reaction was 15 initiated by the addition of 50  $\mu$ g (50  $\mu$ l) of membrane protein. After incubation at 35°C for 10 min. in a shaking water bath, the reaction was terminated by the addition of 100  $\mu$ M EDTA and boiling for 3 min. cAMP was extracted and quantitated by radioimmunoassay using a kit 20 obtained from New England Nuclear, Boston, MA.

#### In Vivo Assays

Any suitable in vivo model system can be used to evaluate the antagonistic properties of the compounds of the invention. Such models, without limitation, include 25 those used to evaluate feeding and memory behavior (Flood et al., *Peptides* 10:963-966), and vasoconstriction and hypertension (Balasubramaniam et al. *Biochim et Biophys Acta* 997: 176-188, 1989).

Thus, in one working example, feeding studies were 30 performed using Sprague Dawley rats (350-450 g) with paraventricular hypothalamic cannulae to investigate effects of NPY analogs (Chance et al. 1989. *Peptides* 10: 1283-1286). Antagonism of NPY induced feeding in rats was by [D-Trp<sup>32</sup>]NPY. Groups of rats received 35 intrahypothalamic injections (1  $\mu$ l) of artificial CSF or

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10  $\mu\text{g}$  of [D-Trp<sup>32</sup>]NPY. Fifteen minutes later CSF-treated rats were injected with CSF (n = 6), 1  $\mu\text{g}$  of NPY (n = 6) or 10  $\mu\text{g}$  of [D-Trp<sup>32</sup>]NPY (n = 7), while the [D-Trp<sup>32</sup>]NPY-treated rats were injected with 1  $\mu\text{g}$  of NPY (n = 8).

5 Rats were provided with a known quantity of rat chow, and after 1 hr the food consumed was determined and corrected for spillage a = p < 0.01 vs. CSF; b, not significant vs. CSF; c = p < 0.01 vs. NPY; d = p < 0.05 vs. NPY.

In another working example blood pressure studies 10 were performed to evaluate the antagonistic properties of Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY. The method is as follows, after surgical preparation, three doses of NPY (0.1, 1.0 and 10 nmol/kg) were administered by intravenous push to 7 rats in a randomized order. Each 15 dose was separated by a 20 minute washout period. After obtaining baseline systolic blood pressure (SBP) values, the rats received either 200 nmol/kg of Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY (n=5) or 0.9% saline (n=2) prior to each NPY dose. Change in SBP from basal state to maximum SBP 20 observed following NPY was compared between baseline and Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY treatments. The duration of SBP effect of Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY was determined in 3 animals by administering 1.0 nmol/kg of NPY every 15 minutes for 75 minutes following 25 a single 200 nmol/kg dose of Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY.

#### RESULTS

We first synthesized a series of full length 30 analogs of NPY substituting either D-Trp or D-Trp(CHO) in the C-terminal receptor binding region at positions 32, 34 and 36. We tested for agonist activity on isoproterenol-stimulated hypothalamic adenylyl cyclase activity. Fig. 1 shows that at 1.0  $\mu\text{M}$ , NPY, [D-Trp<sup>34</sup>]NPY, [D-Trp<sup>36</sup>]NPY, and the corresponding formulated D-Trp

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analogs inhibited isoproterenol-stimulated hypothalamic adenylate cyclase activity significantly. [D-Trp<sup>32</sup>]NPY and its formulated derivative, however, did not exhibit significant inhibitory effect on adenylate cyclase

5 activity at this concentration. In the binding experiments shown in Fig. 2, NPY and [D-Trp<sup>32</sup>]NPY inhibited <sup>125</sup>I-NPY bound to rat hypothalamic membranes in a dose-dependent manner with IC<sub>50</sub> values of 0.63 nM and 3.0 nM, respectively. It is this high receptor activity 10 and the complete loss of intrinsic activity that suggests that [D-Trp<sup>32</sup>]NPY may be an antagonist of NPY in rat hypothalamus.

The complete loss of intrinsic activity, while retaining high binding potency suggested that [D-Trp<sup>32</sup>]NPY 15 may be an antagonist of NPY in hypothalamus. In order to further substantiate this observation, we investigated the inhibitory effect of NPY on rat hypothalamic membrane adenylate cyclase activity both in the absence and presence of [D-Trp<sup>32</sup>]NPY. Fig. 3 shows that NPY inhibited 20 isoproterenol stimulated hypothalamic membrane adenylate cyclase activity dose-dependently with an IC<sub>50</sub> value 0.18 nM. [D-Trp<sup>32</sup>]NPY did not exhibit any inhibitory effect on adenylate cyclase activity. Further, Fig. 3 shows that the presence of 30 and 300 nM [D-Trp<sup>32</sup>]NPY shifted the 25 inhibitory dose-response curve of NPY on hypothalamic adenylate cyclase activity to the right increasing that IC<sub>50</sub> value to 4.0 nM (K<sub>B</sub> = 1.41 nM) and 540. nM (K<sub>B</sub> = 1.36 nM), respectively.

To assess the specificity of [D-Trp<sup>32</sup>]NPY, we 30 investigated its effect on the inhibitory hypothalamic adenylate cyclase activity of serotonin. Fig. 4 shows that the presence of serotonin (100 nM) significantly (p < 0.01; by repeated measures ANOVA) inhibited the isoproterenol stimulate adenylate cyclase activity both 35 in the absence and presence of [D-Trp<sup>32</sup>]NPY (1  $\mu$ M). The

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antagonism at [D-Trp<sup>32</sup>]NPY, therefore, was specific to the NPY receptor since the analog exhibited no effect on the inhibitory hypothalamic AC activity of serotonin and, thus, did not act as a global antagonist.

5 Since hypothalamic NPY has been shown to elicit a feeding response, we also investigated the effect of [D-Trp<sup>32</sup>]NPY on NPY induced feeding in freely moving rats. Fig. 5 shows that intrahypothalamic injection of NPY (1  $\mu$ g) significantly ( $p < 0.01$ ) stimulated the cumulative 10 food intake as compared to vehicle (artificial cerebrospinal fluid) treatment over 1 hr. On the other hand, [D-Trp<sup>32</sup>]NPY (1  $\mu$ g) did not stimulate feeding significantly over this period, nor did it attenuate NPY (1  $\mu$ g) - induced feeding at this concentration. 10  $\mu$ g of 15 [D-Trp<sup>32</sup>]NPY also did not exhibit significant effect on feeding, and at this dose significantly ( $p < 0.05$ ) attenuated the 1 hr. cumulative food intake induced by 1  $\mu$ g of NPY. All of these observations suggest that D-Trp<sup>32</sup> is a specific and competitive antagonist at NPY in rat 20 hypothalamus in both in vitro and in vivo models.

In order to improve the potency and/or selectivity, several analogs were synthesized substituting the residue at 32 with various amino acids, e.g., D-Nal, D-Phe, D-Hyp, or L-Trp (Fig. 6). However, 25 these analogs exhibited agonistic activity which suggests there are strict structural requirements to induce antagonistic properties to NPY. Although it is generally believed that the NPY effects on blood pressure and feeding are mediated by the Y-1 receptor subtype, it is 30 possible that NPY analogs which elicit pressor effects have no orexigenic effects. Thus, [D-Trp<sup>32</sup>]NPY is useful not only to elucidate the receptor subtypes mediating NPY effects on hypothalamus, but also to determine whether feeding and pressor effects are mediated by the Y-1 35 receptors.

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Next, the relative binding affinities of various compounds having formula (I) were investigated using SK-N-MC (Y-1) and SK-N-BE2(Y-2) shown in Table I. These studies led to the development of two truncated peptide 5 analogs, Des-AA<sup>7-24</sup>[Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY and Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY, which did not inhibit the cAMP production by SK-N-MC cells (see Table I). However, Des-AA<sup>7-24</sup>[Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY exhibited poor affinity to Y-1 receptors (Table I), and therefore, failed to antagonize 10 the inhibitory effects of NPY on SK-N-MC cAMP production. On the other hand, Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY, surprisingly exhibited moderate affinity (Table I), and its presence (1.0  $\mu$ M) shifted the inhibitory dose-response curve of NPY on SK-N-MC cAMP production parallel 15 to the right (Fig. 7). These observations confirm that Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY is a competitive antagonist of NPY in Y-1 receptors.

To investigate whether these compounds retained antagonistic activity within an in vivo model, we tested 20 the effects on NPY-induced anorectic rats. Fig. 8 shows that NPY doses of 0.1, 1.0 and 10.0 nmol/kg, during baseline, increased systolic blood pressure (SBP) by 8 $\pm$ 7, .26 $\pm$ 6 and 37 $\pm$ 7 mmHg respectively. Following administration of Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY, NPY 25 doses of 0.1, 1.0 and 10.0 nmol/kg increased SBP by 4 $\pm$ 5, 9 $\pm$ 5 and 29 $\pm$ 17 mmHg respectively. The change in SBP during Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY was significantly different than baseline values ( $p = 0.0002$  at the 1.0 nmol/kg NPY doses, but not at the 0.1 or 10 30 nmol/kg doses. Changes in SBP in control rats receiving saline were not significantly different than baseline values at all NPY doses. The duration of effect of the antagonist ranged between 30-75 minutes. This result demonstrates that Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY is 35 effective in attenuating NPY induced vasoconstriction in

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vivo. Its ability to only affect SBP at the middle NPY dose and the finding that Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY can inhibit the binding of <sup>125</sup>I-NPY to SK-N-MC cells, suggests that Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY 5 competitively antagonizes NPY induced hypertension.

In addition, further truncation and deletion of Des-AA<sup>7-24</sup>[D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY resulted in the development of three analogs (Table I). Although these analogs did not bind to Y-2 receptors, both [D-Ala<sup>28</sup>], D-Trp<sup>32</sup>]NPY(27-36) and [Bip<sup>27</sup>, D-Ala<sup>28</sup>, D-Trp<sup>32</sup>]NPY(27-36) 10 also exhibited poor affinity to Y-1 receptor. However, Des-Asn<sup>29</sup>[D-Trp<sup>28,32</sup>]NPY(27-36) bound with moderate potency to Y-1 receptors, and also did not exhibit any intrinsic activity on isoproterenol stimulated cAMP 15 production by SK-N-MC cells. These observations suggest that Des-Asn<sup>29</sup>[D-Trp<sup>28,32</sup>]NPY(27-36) or its analogs will prove useful for the development low molecular weight selective antagonist compounds for Y-1 receptors.

TABLE I

20	Peptides	IC <sub>50</sub> (nM) for the inhibition of <sup>125</sup> I-NPY binding to	
		SK-N-MC (Y-1)	SK-N-BE2 (Y-2)
	NPY	1.3	0.1
25	[D-Trp <sup>32</sup> ]NPY	1000	0.63
	Des-AA <sup>7-24</sup> [Aoc <sup>6</sup> ,D-Trp <sup>32</sup> ]NPY	3900	10.0
	Des-AA <sup>7-24</sup> [D-Ala <sup>5</sup> , Aoc <sup>6</sup> ,D-Trp <sup>32</sup> ]NPY	100	1.0
	[D-Ala <sup>28</sup> , D-Trp <sup>32</sup> ]NPY(27-36)	630	N.I.
30	[Bip <sup>27</sup> , D-Ala <sup>28</sup> , D-Trp <sup>32</sup> ]NPY(27-36)	1300	N.I.
	Des-Asn <sup>29</sup>		
	[D-Trp <sup>28,32</sup> ]NPY(27-36)	170	N.I.

35 N.I.: no inhibition even at 10,000 nM

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The analogs of the invention may also be assayed and tested for NPY receptor Y-2 activity using the methods described *supra*. Thus, a compound, e.g., [D-Trp<sup>32</sup>]NPY, can be assayed for antagonism using any Y-2 receptor bearing cell, e.g., the SK-N-BE2 cell line, or such cells found in the spleen, kidney, hippocampus or dorsal root ganglion.

Towards developing selective agonists and antagonists of Y-2 receptors, we tested a number of 10 compounds using SK-N-BE2 cell lines. These studies demonstrated that NPY(18-36), previously shown to be an antagonist of NPY in rat cardiac membranes bearing Y-3 receptors, antagonizes the inhibitory effect on the cAMP production of SK-N-BE2 cells bearing Y-2 receptor 15 subtypes as shown in Figures 9 and 10.

NPY RECEPTOR (Y-3 SUBTYPE)

Next, we investigated the effect of introducing a pseudopeptide bond to NPY\*18-36). Table II shows the results for the increased affinity and selectivity of 20 pseudopeptide analogs of NPY(18-36) for Y-3 receptors. The introduction of pseudobonds (-CH<sub>2</sub>NH-) at positions 31-32 or 32-33 of NPY(18-36) was found to substantially increase Y-3 receptor affinity (see Table 2). Subsequent experiments revealed that all these analogs retain their 25 antagonistic properties. Furthermore, [ $\psi^{30/31}$ ]NPY(18-36) and [ $\psi^{31/32}$ ]NPY(18-36) and [ $\psi^{32/33}$ ]NPY(18-36) analogs exhibit lower affinity to Y-1 and Y-2 subtypes than NPY(18-36) (Table II). Thus, introduction of pseudobonds at 32-33 and 31-32 also increases their selectivity for 30 Y-3 receptors.

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TABLE II

PEPTIDES	IC <sub>50</sub> (nM) for the inhibition of <sup>125</sup> I-NPY binding to:	Y-3 (CARDIAC)	Y-2 (SK-N-BE2)	Y-1 (SK-N-MC)
5				
NPY		0.20	0.1	1.3
NPY(18-36)		126	3.00	251
[ $\Psi^{32-33}$ ]NPY(18-36)		0.56	158	1585
[ $\Psi^{31-32}$ ]NPY(18-36)		1.00	562	1995
10 [ $\Psi^{30-31}$ ]NPY(18-36)		6.00	281	N.D.

$\Psi$ , -CH<sub>2</sub>NH-; N.D., not determined.

#### EXAMPLES

This invention is further illustrated by the  
15 following nonlimiting examples.

##### EXAMPLE 1

###### Synthesis of [D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>]NPY

Peptide Synthesis -- MBHA resin (0.45 mM NH<sub>2</sub> group) was placed in a reaction vessel of the Applied Bioscience  
20 (ABI) 430A automated instrument and amino acid derivatives were coupled automatically using the standard program provided by the manufacturer modified to incorporate a double coupling procedure. All amino acids were coupled using 2.2 equivalents of preformed  
25 symmetrical anhydrides. Arg, Asn and Gln, however, were coupled as preformed 1-HOBT esters (4.4 equiv.) to avoid deamidation or lactam formation. At the end of the

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synthesis N- $\alpha$ -Boc-group was removed and peptide resin (~1g) was treated with HF as described below.

In the reaction vessel 1.0 g peptide resin, 0.8 g p-cresol, 0.2g thiocresol, 0.8 ml  $(CH_3)_2$ S and 5 ml HF were stirred for 40 min of reaction and an additional 60 min. of HF evacuation. During these procedures temperature of reaction vessel was kept between 0°C - 4°C. Then the peptide resin was transferred into a fitted filter funnel in  $Et_2O$  and washed with excess of  $Et_2O$ . Free peptide was extracted with 30% HOAc (2x15ml). Peptide solution was diluted to 10% HOAc (60ml  $H_2O$ ) and lyophilized. 390 mg crude peptide was obtained from this procedure.

#### EXAMPLE 2

##### 15 Synthesis of [D-Trp<sup>32</sup>] NPY

Peptide synthesis was performed as described above. Cleavage by HF was as follows: in a reaction vessel 1.0g peptide resin, 0.8 ml  $(CH_3)_2$ S, 0.8g p-cresol, 0.2g p-thiocresol and 5ml HF were stirred for 40 min of reaction in temperature between 0°C - 4°C. After that HF was evacuated in 60. Temperature was still kept below 0°C. The peptide resin was transferred into fitted filter funnel and washed with excess of  $Et_2O$ . The peptide resin extracted with 30ml 30% HOAc. Peptide solution was diluted to 10% HOAc with 60ml  $H_2O$  and protein lyophilized. Total weight of crude peptide: 190mg.

#### EXAMPLE 3

##### Synthesis of Cyclo(7/21), Des-AA<sup>10-17</sup>[Cys<sup>7,21</sup>,D-Trp<sup>32</sup>] NPY

Peptide synthesis was as described above using an 30 Automated ABI 430A synthesizer. The free peptide was obtained by treating the protected peptide resin (1.0g) with HF (10 ml) containing dimethyl sulfide (0.8 ml), p-cresol (0.2g) for 1 h at -2 to -4 C. The residue was

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transferred to a fitted filter funnel with diethyl ether, washed repeatedly with diethyl ether, and the peptide extracted with 10% HOAC(2X 15 ml) and lyophilized. The crude peptide (100mg) thus obtained was dissolved in 6M 5 guanidine HCL (6 ml) diluted with 500 ml of distilled water and the pH adjusted to 8 with ammonia. A solution of potassium ferricyanide (1% w/v) was gradually added with constant stirring until a yellow color persisted. After stirring for an additional 30 min., the pH of the 10 solution was adjusted to 5 with acetic acid and the solution stirred with an anion exchange resin (AG-3, Cl-form, 10g wet weight) for 30 min, passed through a 0.45 microns filter, and pumped into a semipreparative column (250X10 mm), washed with 0.1%TFA-H<sub>2</sub>O until a flat base 15 line was obtained. The column containing the peptide was then subjected to gradient elution as described for NPY, and the purified peptide was characterized by amino acid and mass spectral analysis.

**EXAMPLE 4**

20 **Synthesis of Cyclo(7/21), Des-AA<sup>10-17</sup>[Glu<sup>7</sup>, Lys<sup>21</sup>, D-Trp<sup>32</sup>]NPY**

The synthesis of this peptide was accomplished using the general strategy described for NPY except for the following: After coupling BocGlu(OFM) at position 7, the 25 side chain protecting groups,  $\epsilon$ -Fmoc group at Lys<sup>21</sup> and the  $\gamma$ ORm of Glu<sup>7</sup> were removed by removing the peptide resin with 20% piperidine-DMF. After repeated washings with DMF, the  $\epsilon$ -NH<sub>2</sub> group of Lys<sup>21</sup> was coupled to  $\gamma$ -COOH of Glu<sup>7</sup> by stirring the peptide resin with BOP-HOBT-DIPEA 30 (1:1:3) in DMF (20 ml) overnight, and if cyclization is not complete as judged by the standard ninhydrin test the procedure was repeated until complete cyclization has occurred. The synthesis was then continued in the

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automated mode, and the free peptide was obtained by the standard HF method described in Example 3.

**Example 5**

**Synthesis of [ $\psi$ 32/33]NPY (18-36)**

5 Standard techniques, as described above, were employed for the solid phase synthesis of the carboxy terminal portion of cardiac receptor antagonist, NPY [ $\psi$ 32/33]NPY (18-36), up to the point at which introduction of the pseudopeptide bond was desired. The pseudopeptide 10 bond was then introduced in the analog according to the method of Sasaki et al. (Peptides 8:119-121, 1986), with Boc as the protecting group for the primary amine.

The resulting N- $\alpha$ -Boc-peptide-resin with the pseudopeptide bond (0.25 mmol) was swollen in DMF (10 ml) 15 for 10 min in a two-necked R.B. flask fitted with a drying tube. This was followed by the addition of diisopropylethyl amine (1.0 mmol), HOBt (0.5 mmol) and Z(2-Cl)OSU (0.5 mmol). HOBt enhances the coupling of Z(2-Cl) to the secondary amino group of the pseudopeptide 20 bond. The reaction mixture was stirred at room temperature until the Kaiser's ninhydrin test gave a yellow color indicating that the secondary amine had been blocked. The peptide resin was returned to the reaction vessel of the automated peptide synthesizer and the rest 25 of the sequence was assembled automatically. The free peptide was obtained by the standard cleavage conditions and purified by reverse phase chromatography.

**USE**

Because NPY is a potent vasoconstrictor and or 30 orexigenic agent, as well as an inhibitor of libido and effector of circulation rhythm, it is likely that the administration of one or more compounds of the invention may suppress or inhibit the deleterious effects of NPY.

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Therefore, the NPY antagonists of the invention are suitable for the treatment of any number of diseases related to cardiovascular function (e.g., congestive heart failure or hypertension), obesity, anorexia, blood pressure, asthma, pulmonary hypertension, renal hypertension, memory retention, sexual dysfunction (e.g. impotence), and disorders involving sleep and circadian rhythms. For example, the compounds of formula (I), (II), (III) are useful for treating for controlling feeding disorders and blood pressure; the compounds of formula (IV) are useful for treating any number of heart ailments, e.g., chronic heart failure, as well as promoting recovery from ischemia since the compounds are expected to enhance myocardium contraction; and the compounds of formula (IV) are useful for controlling NPY actions mediated by Y-2 receptor subtypes, e.g., for controlling the effects of NPY on renal blood flow, glomerular filtration rate, natriuresis and renin secretion.

Thus to treat the above disorders, the appropriate NPY antagonist is administered as a therapeutic preparation (as described below) in accordance with the condition to be treated. In the practice of the method of the present invention, an effective amount of an NPY antagonist, e.g.,  $\text{P}^{30-31}\text{NPY}(18-36)$ , is administered via any of the usual and acceptable methods known in the art, either singly or in combination with another compound or compounds of the present invention. These compounds or compositions can thus be administered orally, sublingually, parenterally (e.g., intramuscularly, intravenously, subcutaneously, or intradermally) or by inhalation, and in the form of either solid, liquid or gaseous dosage, including tablets and suspensions. The administration can be conducted in a single unit dosage

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form with continuous therapy or in a single dose therapy ad libitum.

The dose of the compound of the present invention for treating the above-mentioned disorders varies  
5 depending upon the manner of administration, the age and the body weight of the subject, and the condition of the subject to be treated, and ultimately will be decided by the attending physician or veterinarian. Such amount of the active compound as determined by the attending  
10 physician or veterinarian is referred to herein as a "therapeutically effective amount". Thus, a typical administration is oral administration or parenteral administration. The daily dose in the case of oral administration is typically in the range of 0.1 to 100  
15 mg/kg body weight, and the daily dose in the case of parenteral administration is typically in the range of 0.001 to 50 mg/kg body weight.

To be effective for the prevention or treatment of the above-mentioned disorders it is important that the  
20 therapeutic agents be relatively non-toxic, non-antigenic and non-irritating at the levels in actual use.

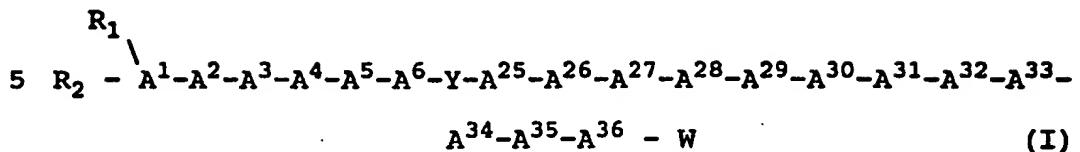
It is understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof  
25 will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and scope of the appended claims.

Other embodiments are within the following claims.

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CLAIMS

1. A compound having the formula:



wherein

each  $R_1$  and  $R_2$ , independently, is H,  $C_1-C_{12}$  alkyl,

10  $C_6-C_{18}$  aryl,  $C_1-C_{12}$  acyl,

$C_7-C_{18}$  aralkyl, or  $C_7-C_{18}$  alkaryl;

$A^1$  is Tyr, or any aromatic amino acid;

$A^2$  is Pro, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , D-Pal or Asp;

$A^3$  is Ser, Thr, N-Me-Ser, N-Me-Thr, Ile, Val, Aib, Anb,

15 Nle, or N-Me-Leu;

$A^4$  is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain  $C_1-C_{10}$  alkyl group, or a  $C_6-C_{18}$  aryl group), or Orn;

20  $A^5$  is Pro, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , D-Pal, or D-Trp;

$A^6$  is Gly or is the D- or L- isomer selected from the group consisting of Asp, Glu, N-Me-Asp, Ala, or Aoc;

25 Y is  $A^7 - A^8 - A^9 - A^{10} - A^{11} - A^{12} - A^{13} - A^{14} - A^{15} - A^{16} - A^{17} - A^{18} - A^{19} - A^{20} - A^{21} - A^{22} - A^{23} - A^{24}$  or is absent, where

$A^7$  is Asn, Ala, Gln, Gly, or N-Me-Asn;

$A^8$  is Pro, Ser, Thr, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , or D-Pal;

30  $A^9$  is Gly, N-Me-Gly, Ala, or Trp;

$A^{10}$  is Glu, Asp, N-Me-Glu, Ala, or Nva;

$A^{11}$  is Asp, Glu, N-Me-Asp, Ala, or Anb;

$A^{12}$  is Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

$A^{13}$  is Pro, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , D-Pal,

35 Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal, Thi, Phe, Bth, Pcp, N-Me-Ala, or Thr;

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A<sup>14</sup> is Ala, Pro, Hyp, D-Ala, N-Me-Ala, Ac<sub>6</sub>C, D-Pal, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

5 A<sup>15</sup> is Glu, Asp, N-Me-Glu, Ala, or Nva;

A<sup>16</sup> is Asp, Glu, N-Me-Asp, Ala, or Anb;

A<sup>17</sup> is Met, Leu, Ile, Val, Aib, Anb, Nle, or N-Me-Leu;

A<sup>18</sup> is Ala, Asn, Gln, Gly, N-Me-Asn, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

10 A<sup>19</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys-ε-NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

15 A<sup>20</sup> is Tyr, or any aromatic amino acid;

A<sup>21</sup> is Tyr, any aromatic amino acid;

A<sup>22</sup> is Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

20 A<sup>23</sup> is Ala, Ser, Thr, Nal, Thi, Phe, Bth, Pcp, N-Me-Ala, N-Me-Ser, or N-Me-Thr;

A<sup>24</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

25 A<sup>25</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys-ε-NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

30 A<sup>26</sup> is the D- or L- isomer of selected from the group consisting of His, Thr, 3-Me-His, β-pyrazolylalanine, N-Me-His, Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys-ε-NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

- 47 -

A<sup>27</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid, Lys, or a tethered amino acid with an indole ring;

5 A<sup>28</sup> is Aib or is the D- or L- isomer selected from the group consisting of Ile, Leu, Val, Anb, Trp, N-Me-Ile, or is deleted;

A<sup>29</sup> is Asn, Ala, Gln, Gly, N-Me-Asn, or is deleted;

A<sup>30</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

A<sup>31</sup> is Ile, Cys, Leu, Val, Aib, Anb, or N-Me-Ile;

10 A<sup>32</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid except L-Tyr, a tethered amino acid with an indole ring, Ant, Ser, N-Me-Ser, Thr, N-Me-Thr, Ala, N-Me-Ala, D-Hyp, or any Trp derivative;

15 A<sup>33</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), Orn, or is deleted;

20 A<sup>34</sup> is Gln, Asn, N-Me-Gln, Nle, Nva, Ala, or Gly;

A<sup>35</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

25 A<sup>36</sup> is Tyr, or any aromatic amino acid;

W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where each R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub>, independently, is H, C<sub>1</sub>-C<sub>12</sub> alkyl, C<sub>6</sub>-C<sub>18</sub> aryl, C<sub>1</sub>-C<sub>12</sub> acyl, C<sub>7</sub>-C<sub>18</sub> aralkyl, or C<sub>7</sub>-C<sub>18</sub> alkaryl; wherein, in formula (I) each bond can represent either a peptide bond or a pseudopeptide bond, provided that said compound cannot contain more than 3 pseudopeptide bonds, or a pharmaceutically acceptable salt thereof.

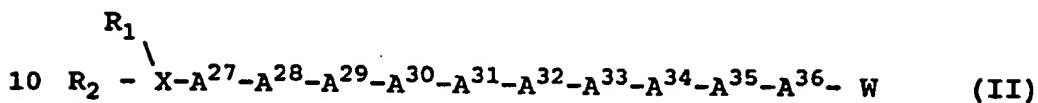
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2. The compound of claim 1, wherein Y (A<sup>7</sup>-A<sup>24</sup>) is absent.

3. The compound of claim 2, wherein said compound has the formula Des AA<sup>7-24</sup>, Aoc<sup>6</sup> D-Trp<sup>32</sup>] NPY.

5 4. The compound of claim 2, wherein said compound has the formula Des AA<sup>7-24</sup> [D-Ala<sup>5</sup>, Aoc<sup>6</sup>, D-Trp<sup>32</sup>] NPY.

5. A compound having the formula:



wherein X is a chain of 0-7 amino acids, inclusive, the N-terminal one of which is bonded to each R<sub>1</sub> and R<sub>2</sub>;

15 wherein each R<sub>1</sub> and R<sub>2</sub>, independently, is each H, C<sub>1</sub>-C<sub>12</sub> alkyl, C<sub>6</sub>-C<sub>18</sub> aryl, C<sub>1</sub>-C<sub>12</sub> acyl, C<sub>7</sub>-C<sub>18</sub> aralkyl, or C<sub>7</sub>-C<sub>18</sub> alkaryl; A<sup>27</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid, Lys, or a 20 tethered amino acid with an indole ring;

20 A<sup>28</sup> is Aib or is the D- or L- isomer selected from the group consisting of Ile, Leu, Val, Anb, Trp, N-Me-Ile, or is deleted;

A<sup>29</sup> is Asn, Ala, Gln, Gly, or N-Me-Asn, or is deleted;

25 A<sup>30</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu, or is deleted;

A<sup>31</sup> is Ile, Cys, D-Ala, Leu, Val, Aib, Anb, or N-Me-Ile, or is deleted;

30 A<sup>32</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid except L-Tyr, a tethered amino acid with an indole ring, Ant, Ser, N-Me-Ser, Thr, N-Me-Thr, Ala, N-Me-Ala, D-Hyp, or any Trp derivative;

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A<sup>33</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), Orn, or is deleted;

5 A<sup>34</sup> is Gln, Asn, N-Me-Gln, Nle, Nva, Ala, or Gly;

A<sup>35</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

10 A<sup>36</sup> is Tyr, or any aromatic amino acid;

W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where each R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub>, independently, is

15 H, C<sub>1</sub>-C<sub>12</sub> alkyl, C<sub>6</sub>-C<sub>18</sub> aryl, C<sub>1</sub>-C<sub>12</sub> acyl, C<sub>7</sub>-C<sub>18</sub> alkaryl or C<sub>7</sub>-C<sub>18</sub> alkaryl; wherein, in formula (II) each bond can represent either a peptide bond or a pseudopeptide bond, provided that said compound cannot contain more than 3 pseudopeptide bonds, or a

20 pharmaceutically acceptable salt thereof.

6. The compound of claim 5, where X is A<sup>20</sup>-A<sup>21</sup>-A<sup>22</sup>-A<sup>23</sup>-A<sup>24</sup>-A<sup>25</sup>-A<sup>26</sup> wherein

A<sup>20</sup> is Tyr, or any aromatic amino acid;

A<sup>21</sup> is Tyr, or any aromatic amino acid;

25 A<sup>22</sup> is Ser, Thr, N-Me-Ser, N-Me-Thr;

A<sup>23</sup> is Ala, Ser, Thr, Nal, Thi, Phe, Bth, Pcp, N-Me-Ala, N-Me-Ser, or N-Me-Thr;

A<sup>24</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

A<sup>25</sup> is the D- or L- isomer selected from the group

30 consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

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$A^{26}$  is the D- or L- isomer selected from the group consisting of His, Thr, 3-Me-His,  $\beta$ -pyrazolylalanine, N-Me-His, Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain  $C_1$ - $C_{10}$  alkyl group, or a  $C_6$ - $C_{18}$  aryl group), or Orn;

5

W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where each R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub>, independently, is

10

H,  $C_1$ - $C_{12}$  alkyl,  $C_6$ - $C_{18}$  aryl,  $C_1$ - $C_{12}$  acyl,  $C_7$ - $C_{18}$  aralkyl, or  $C_7$ - $C_{18}$  alkaryl; or a pharmaceutically acceptable salt thereof.

7. The compound of claim 5 having the formula [D-Ala<sup>28</sup>, D-Trp<sup>32</sup>]NPY (27-36).

15

8. The compound of claim 5, having the formula Des-Asn<sup>29</sup> [D-Trp<sup>28,32</sup>]NPY(27-36).

9. A compound having the formula:

20 
$$\begin{array}{c} R_1 \\ | \\ A^1-A^2-A^3-A^4-A^5-A^6-A^7-A^8-A^9-Y-A^{18}-A^{19}-A^{20}-A^{21}-A^{22}-A^{23}-A^{24} \\ | \\ R_2 \\ -A^{25}-A^{26}-A^{27}-A^{28}-A^{29}-A^{30}-A^{31}-A^{32}-A^{33}-A^{34}-A^{35}-A^{36}-W \end{array} \quad (\text{III})$$

25

wherein a disulfide bond is between A<sup>7</sup> and A<sup>21</sup> or is absent; wherein

30

each R<sub>1</sub> and R<sub>2</sub>, independently, is H,  $C_1$ - $C_{12}$  alkyl,  $C_6$ - $C_{18}$  aryl,  $C_1$ - $C_{12}$  acyl,  $C_7$ - $C_{18}$  aralkyl, or  $C_7$ - $C_{18}$  alkaryl;

A<sup>1</sup> is Tyr, or any aromatic amino acid;

A<sup>2</sup> is Pro, Hyp, D-Ala, N-Me-Ala, Ac<sub>6</sub>C, D-Pal or Asp;

A<sup>3</sup> is Ser, Thr, N-Me-Ser, N-Me-Thr, Ile, Val, Aib, Anb, Nle, or N-Me-Leu

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$A^4$  is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain  $C_1-C_{10}$  alkyl group, or a  $C_6-C_{18}$  aryl group), or Orn;

$A^5$  is Pro, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , D-Pal, or D-Trp;

$A^6$  is Gly or is the D- or L- isomer selected from the group consisting of Asp, Glu, N-Me-Asp, Ala, or Aoc;

10  $A^7$  is Cys, Glu, Asn, Ala, Gln, Gly, or N-Me-Asn;

$A^8$  is Pro, Ser, Thr, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , or D-Pal;

$A^9$  is Gly, N-Me-Gly, Ala, or Trp;

Y is  $A^{10}-A^{11}-A^{12}-A^{13}-A^{14}-A^{15}-A^{16}-A^{17}$  or is absent, where

15  $A^{10}$  is Glu, Asp, N-Me-Glu, Ala, or Nva;

$A^{11}$  is Asp, Glu, N-Me-Asp, Ala, or Anb;

$A^{12}$  is Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

$A^{13}$  is Pro, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , D-Pal, Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal, Thi, Phe, Bth, Pcp, N-Me-Ala, or Thr;

20  $A^{14}$  is Ala, Pro, Hyp, D-Ala, N-Me-Ala,  $Ac_6C$ , D-Pal, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

$A^{15}$  is Glu, Asp, N-Me-Glu, Ala, or Nva;

$A^{16}$  is Asp, Glu, N-Me-Asp, Ala, or Anb;

25  $A^{17}$  is Met, Leu, Ile, Val, Aib, Anb, Nle, or N-Me-Leu;

$A^{18}$  is Ala, Asn, Gln, Gly, N-Me-Asn, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

$A^{19}$  is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain  $C_1-C_{10}$  alkyl group, or a  $C_6-C_{18}$  aryl group), or Orn;

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$A^{20}$  is Tyr, or any aromatic amino acid;

$A^{21}$  is Cys, Lys, Tyr, or any aromatic amino acid;

$A^{22}$  is Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

5  $A^{23}$  is Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

$A^{24}$  is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

10  $A^{25}$  is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain  $C_1-C_{10}$  alkyl group, or a  $C_6-C_{18}$  aryl group), or Orn;

$A^{26}$  is the D- or L- isomer selected from the group consisting of His, Thr, 3-Me-His,  $\beta$ -pyrazolylalanine, N-Me-His, Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain  $C_1-C_{10}$  alkyl group, or a  $C_6-C_{18}$  aryl group), or Orn;

15  $A^{27}$  is the D- or L- isomer selected from the group consisting of any aromatic amino acid, Lys, or a tethered amino acid with an indole ring;

20  $A^{28}$  is Aib or is the D- or L- isomer selected from the group consisting of Ile, Leu, Val, Anb, Trp, N-Me-Ile, or is deleted;

25  $A^{29}$  is Asn, Ala, Gln, Gly, N-Me-Asn, or deleted;

$A^{30}$  is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

$A^{31}$  is Ile, Cys, Leu, Val, Aib, Anb, or N-Me-Ile;

30  $A^{32}$  is the D- or L- isomer selected from the group consisting of any aromatic amino acid except L-Tyr, a tethered amino acid with an indole ring, Ant, Ser, N-Me-Ser, Thr, N-Me-Thr, Ala, N-Me-Ala, D-Hyp, or any Trp derivative;

35  $A^{33}$  is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or

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straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), Orn, or is deleted;

A<sup>34</sup> is Gln, Asn, N-Me-Gln, Nle, Nva, Ala, or Gly;

A<sup>35</sup> is the D- or L- isomer selected from the group

5 consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys-ε-NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

A<sup>36</sup> is Tyr, or any aromatic amino acid;

10 W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub>, independently, is

H, C<sub>1</sub>-C<sub>12</sub> alkyl, C<sub>6</sub>-C<sub>18</sub> aryl, C<sub>1</sub>-C<sub>12</sub>

acyl, C<sub>7</sub>-C<sub>18</sub> aralkyl, or C<sub>7</sub>-C<sub>18</sub> alkaryl; wherein,

15 in formula (III) each bond can represent either a peptide bond or a pseudopeptide bond, provided that said compound cannot contain more than 3 pseudopeptide bonds, or a pharmaceutically acceptable salt thereof.

10. The compound of claim 9, having the formula cyclo(7/21), Des AA<sup>10-17</sup>[Cys<sup>7</sup>, Cys<sup>21</sup>, D-Trp<sup>32</sup>]NPY.

20 11. The compound of claim 9, having the formula cyclo(7/21), Des AA<sup>10-17</sup>[Glu<sup>7</sup>, Lys<sup>21</sup>, D-Trp<sup>32</sup>]NPY.

12. A compound with pseudopeptide bonds having the formula:

25 
$$\begin{array}{c} R_1 \\ \backslash \\ R_2 - A^{18}-A^{19}-A^{20}-A^{21}-A^{22}-A^{23}-A^{24}-A^{25}-A^{26}-A^{27}-A^{28}-A^{29}-A^{30}-A^{31}- \end{array}$$

A<sup>32</sup>-A<sup>33</sup>-A<sup>34</sup>-A<sup>35</sup>-A<sup>36</sup> - W (IV)

wherein

30 each R<sub>1</sub> and R<sub>2</sub>, independently, is H, C<sub>1</sub>-C<sub>12</sub> alkyl, C<sub>6</sub>-C<sub>18</sub> aryl, C<sub>1</sub>-C<sub>12</sub> acyl, C<sub>7</sub>-C<sub>18</sub> aralkyl, or C<sub>7</sub>-C<sub>18</sub> alkaryl;

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A<sup>18</sup> is Ala, Asn, Gln, Gly, N-Me-Asn, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

5 A<sup>19</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

10 A<sup>20</sup> is Tyr, or any aromatic amino acid;

A<sup>21</sup> is Tyr, or any aromatic amino acid;

15 A<sup>22</sup> is Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala

A<sup>23</sup> is Ser, Thr, N-Me-Ser, N-Me-Thr, Ala, Nal, Thi, Phe, Bth, Pcp, or N-Me-Ala;

20 A<sup>24</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

25 A<sup>25</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

20 A<sup>26</sup> is the D- or L- isomer selected from the group consisting of His, Thr, 3-Me-His,  $\beta$ -pyrazolylalanine, N-Me-His, Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

25 A<sup>27</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid, Lys, or a tethered amino acid with an indole ring;

30 A<sup>28</sup> is Aib or is the D- or L- isomer selected from the group consisting of Ile, Leu, Val, Anb, Trp, N-Me-Ile, or is deleted;

A<sup>29</sup> is Asn, Ala, Gln, Gly, N-Me-Asn, or is deleted;

A<sup>30</sup> is Leu, Ile, Val, Aib, Anb, or N-Me-Leu;

A<sup>31</sup> is Ile, Cys, Leu, Val, Aib, Anb, or N-Me-Ile;

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A<sup>32</sup> is the D- or L- isomer selected from the group consisting of any aromatic amino acid except L-Tyr, a tethered amino acid with an indole ring, Ant, Ser, N-Me-Ser, Thr, N-Me-Thr, Ala, N-Me-Ala, 5 D-Hyp, or any Trp derivative;

A<sup>33</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl 10 group), Orn, or is deleted;

A<sup>34</sup> is Gln, Asn, N-Me-Gln, Nle, Nva, Ala, or Gly;

A<sup>35</sup> is the D- or L- isomer selected from the group consisting of Lys, Arg, homo-Arg, diethyl-homo-Arg, Lys- $\epsilon$ -NH-R (where R is H, a branched or 15 straight chain C<sub>1</sub>-C<sub>10</sub> alkyl group, or a C<sub>6</sub>-C<sub>18</sub> aryl group), or Orn;

A<sup>36</sup> is Tyr, or any aromatic acid;  
W is -OH, -N-R<sub>3</sub>R<sub>4</sub>, or OR<sub>5</sub> (where R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub>, 20 independently, is H, C<sub>1</sub>-C<sub>12</sub> alkyl, C<sub>6</sub>-C<sub>18</sub> aryl, C<sub>1</sub>-C<sub>12</sub> acyl, C<sub>7</sub>-C<sub>18</sub> aralkyl, or C<sub>7</sub>-C<sub>18</sub> alkaryl; wherein, in formula (IV) each bond can represent either a peptide bond or a pseudopeptide bond, provided that said compound cannot contain more than 2 pseudopeptide bonds, or a pharmaceutically 25 acceptable salt thereof.

13. The compound of claim 1, 5, 9, or 12, wherein a pseudopeptide bond is positioned between A<sup>29</sup> and A<sup>30</sup>.

14. The compound of claim 1, 5, 9, or 12, wherein a pseudopeptide bond is positioned between A<sup>30</sup> and A<sup>31</sup>.

30 15. The compound of claim 1, 5, 9, or 12, wherein a pseudopeptide bond is positioned between A<sup>31</sup> and A<sup>32</sup>.

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16. The compound of claim 1, 5, 9, or 12, wherein a pseudopeptide bond is positioned between A<sup>32</sup> and A<sup>33</sup>.

17. The compound of claim 1, 5, 9, or 12, wherein a pseudopeptide bond is positioned between A<sup>34</sup> and A<sup>35</sup>.

5 18. The compound of claim 1, 5, 9, or 12, wherein a pseudopeptide bond is positioned between A<sup>35</sup> and A<sup>36</sup>.

19. A dimeric compound comprising one compound from either claims 1, 5, 9, or 12 and one compound from either claims 1, 5, 9, or 12, wherein said dimer is  
10 formed by either an amide bond or a disulfide bridge between the two compounds.

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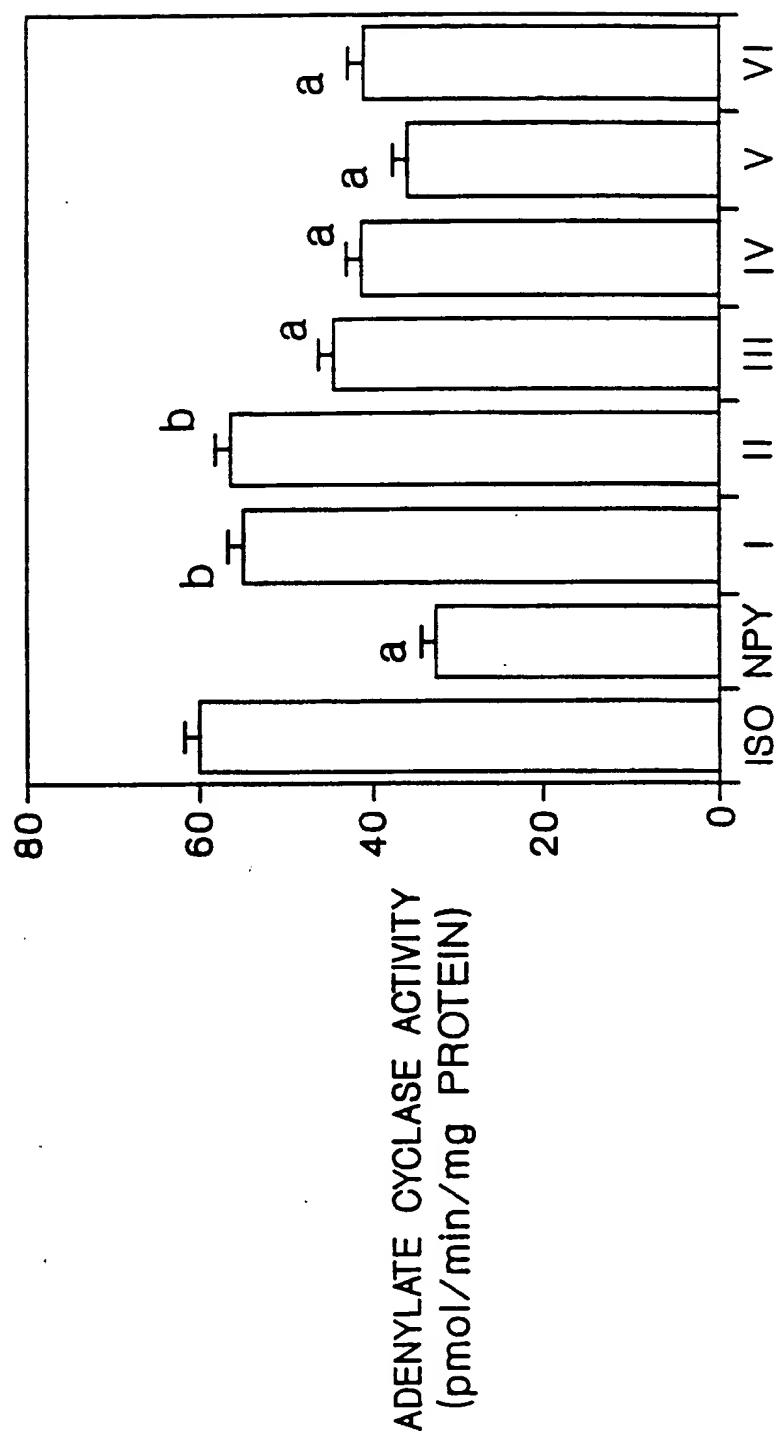


FIG. 1

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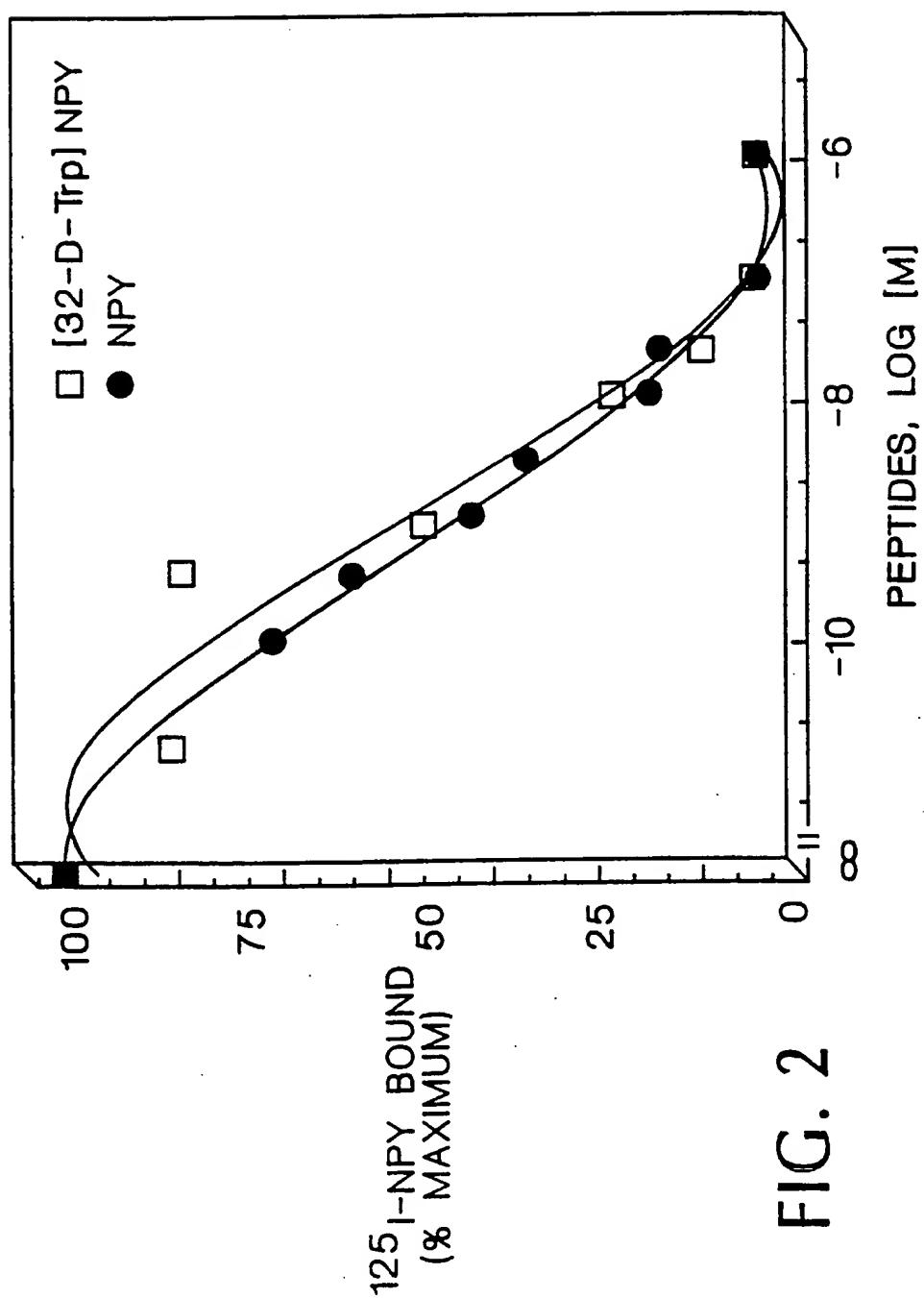


FIG. 2

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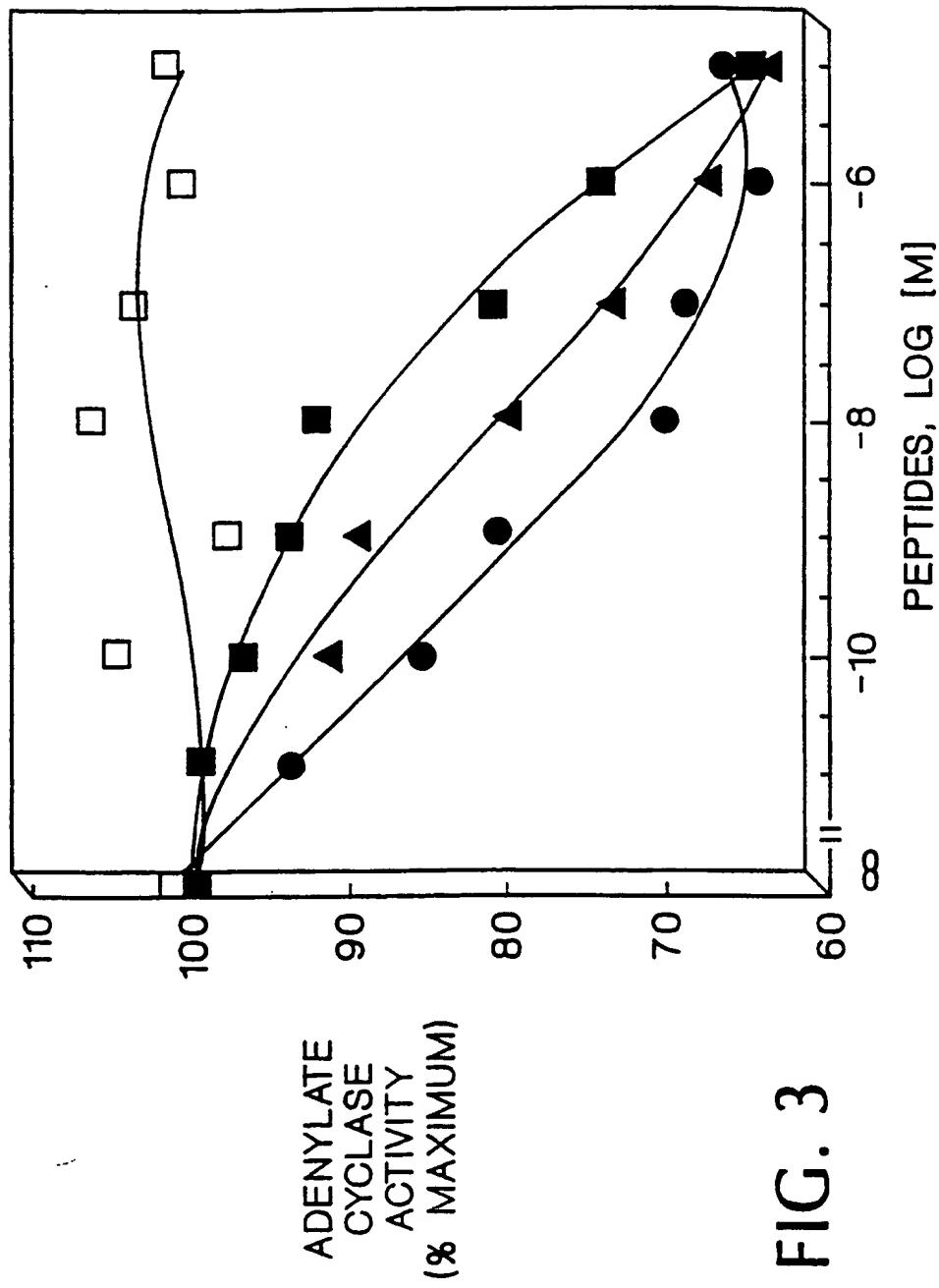


FIG. 3

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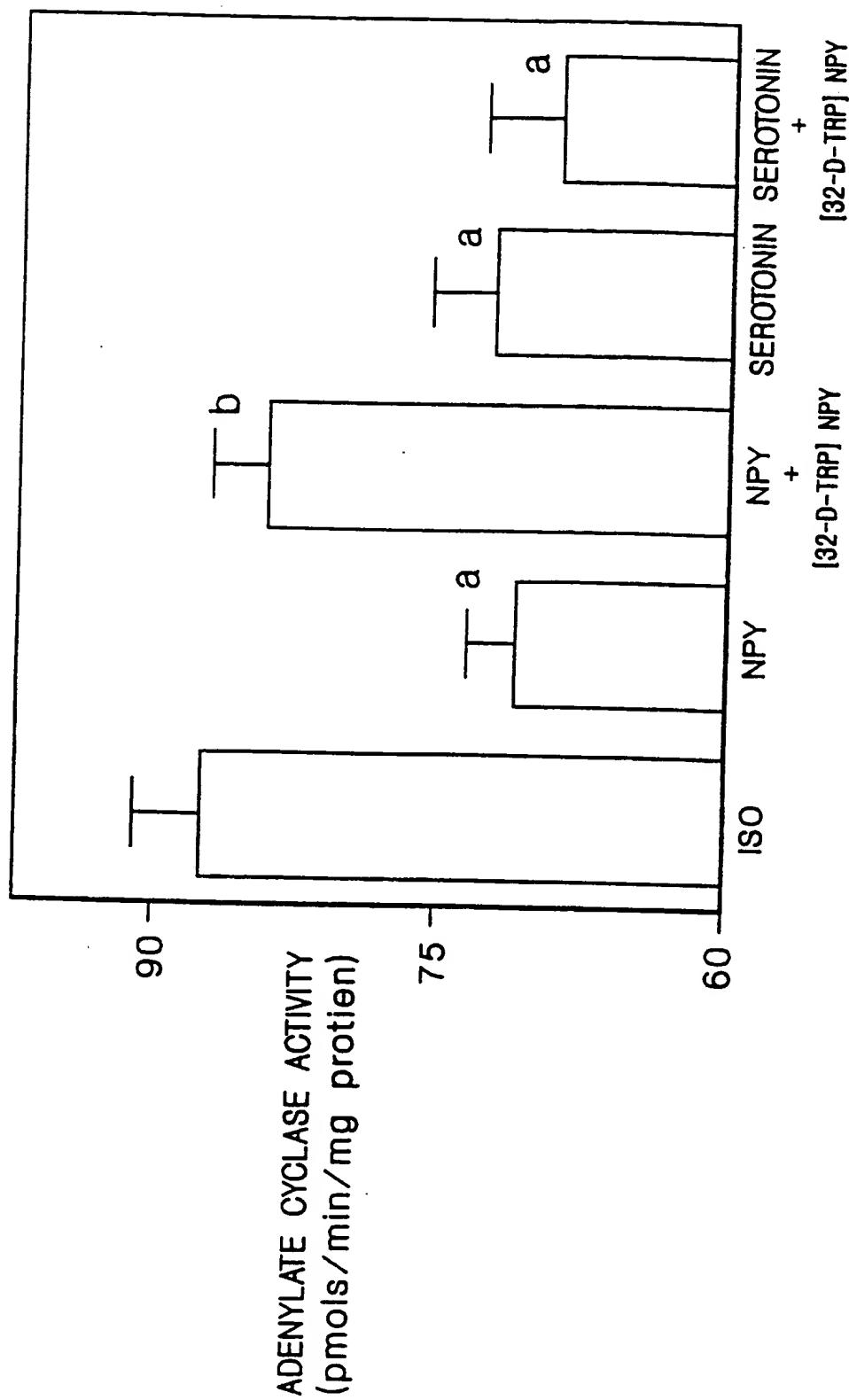


FIG. 4

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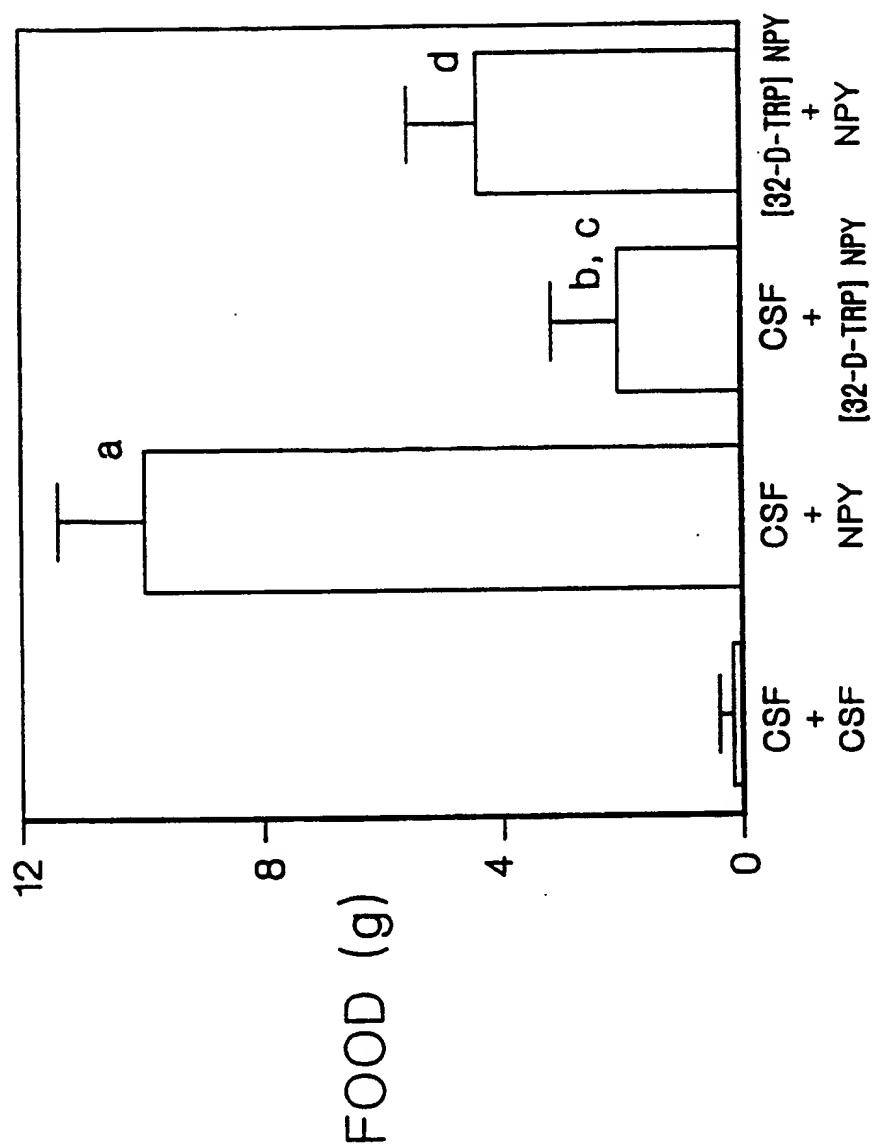


FIG. 5

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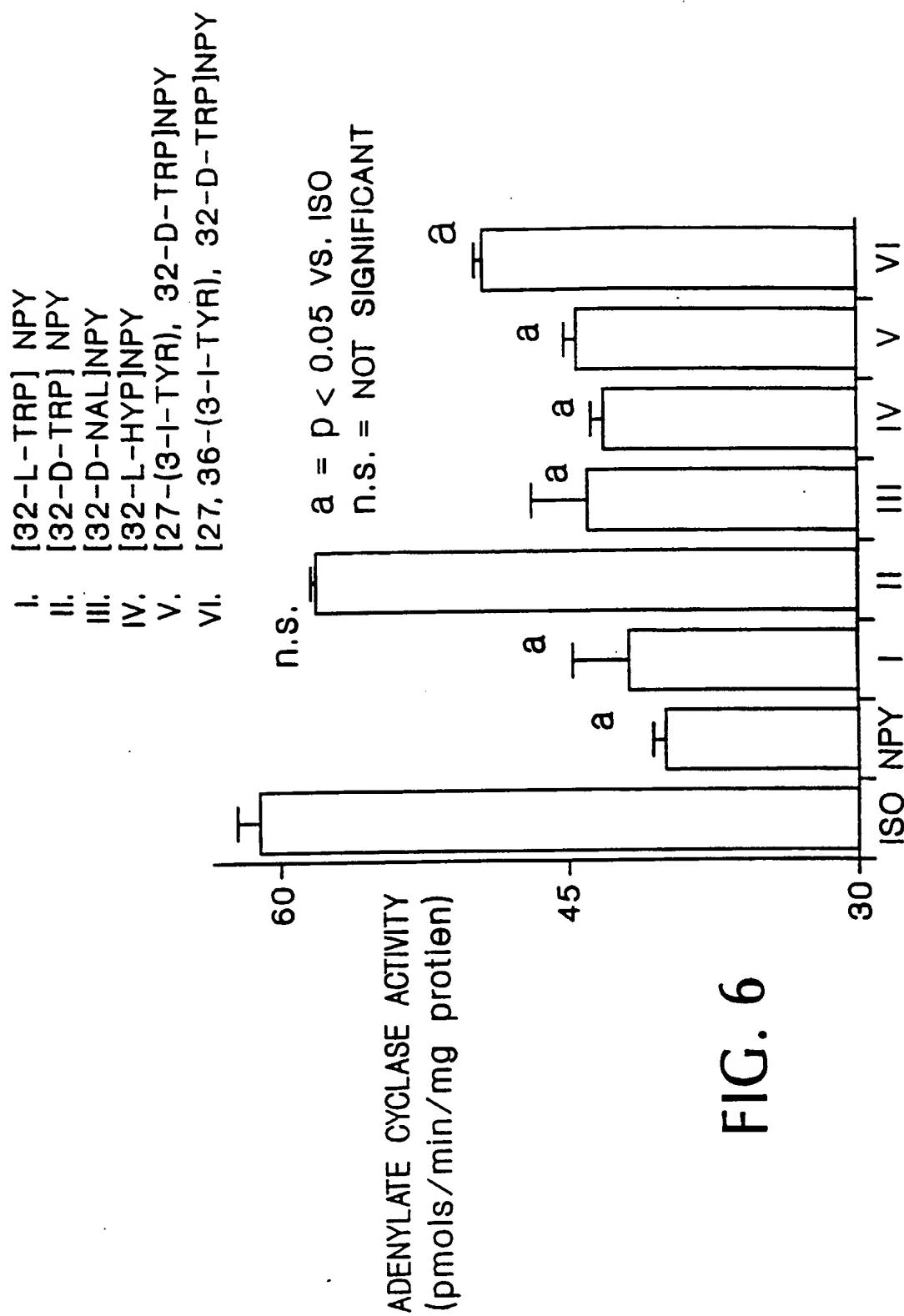


FIG. 6

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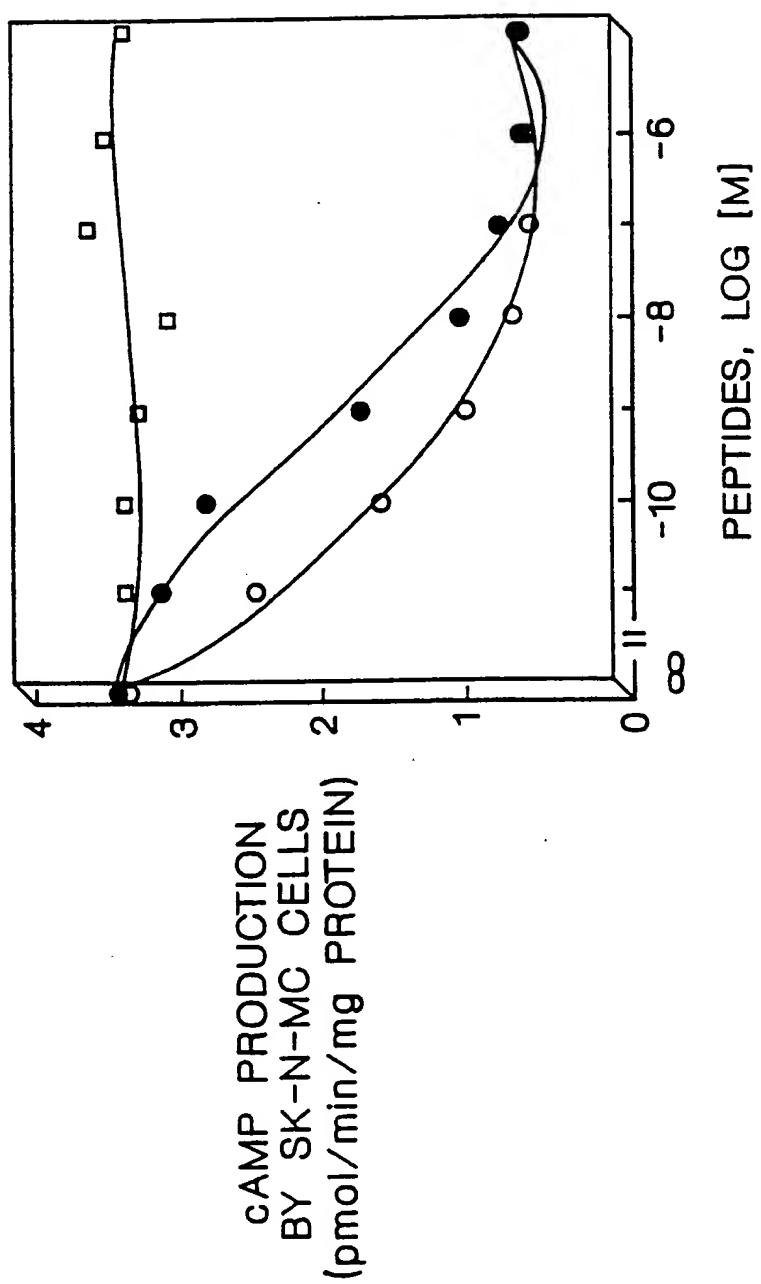


FIG. 7

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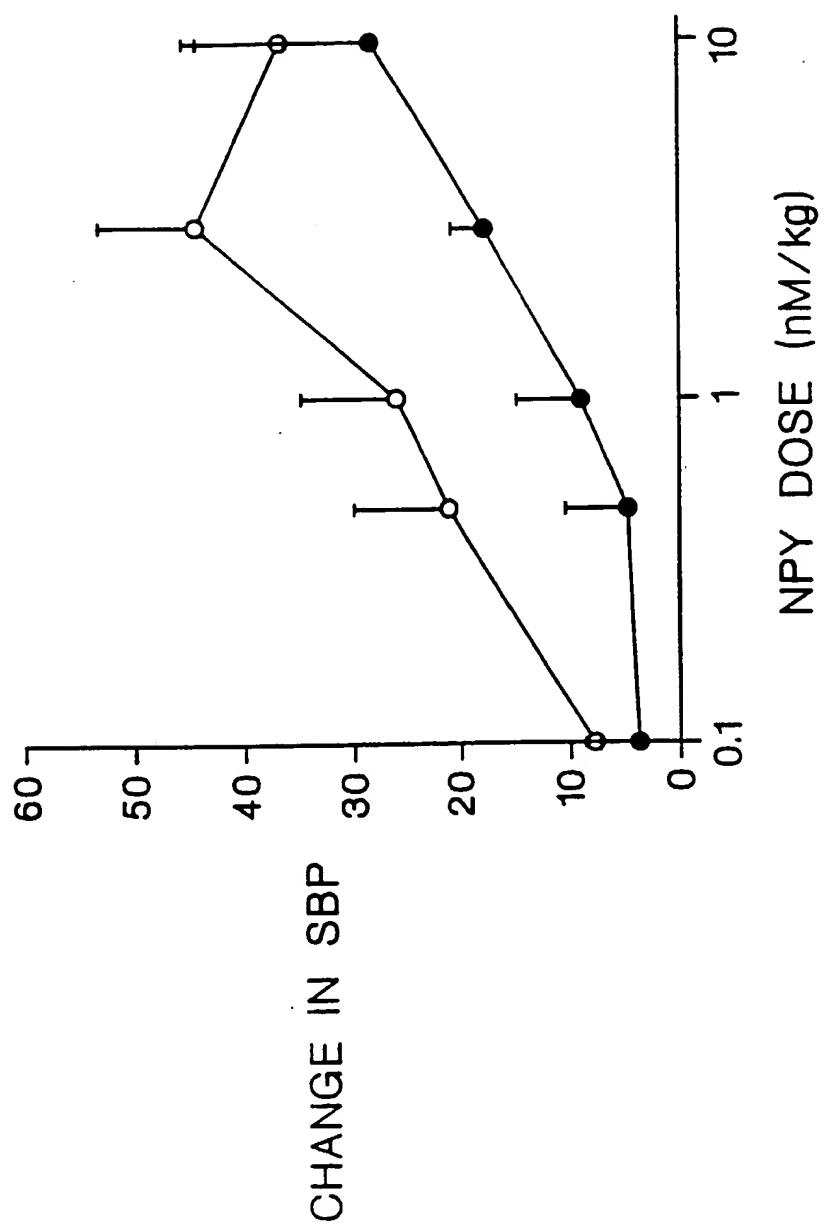


FIG. 8

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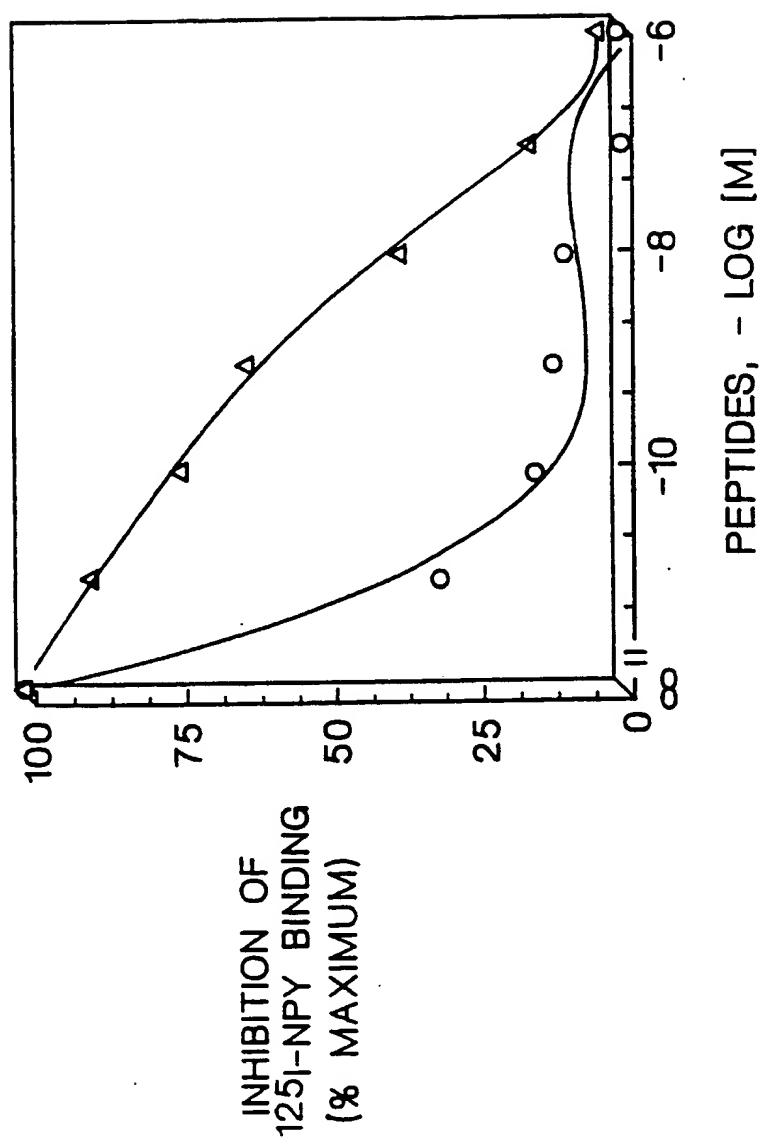


FIG. 9

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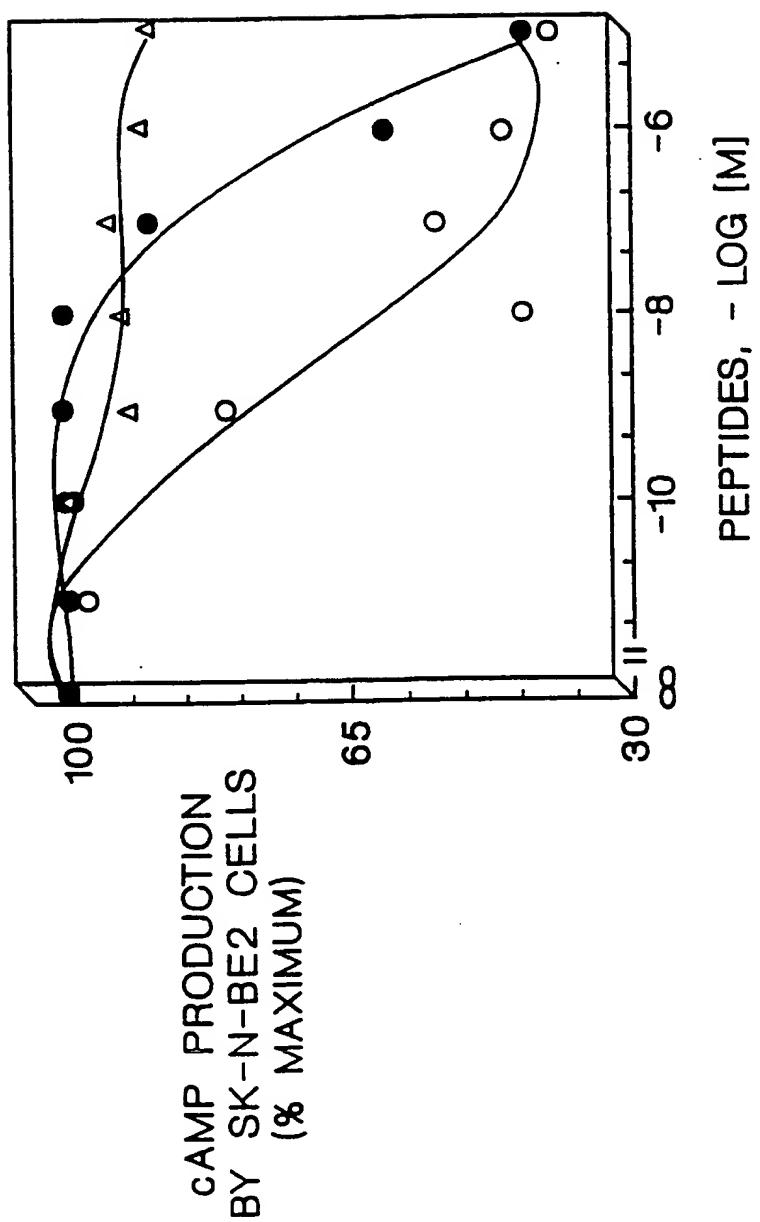


FIG. 10

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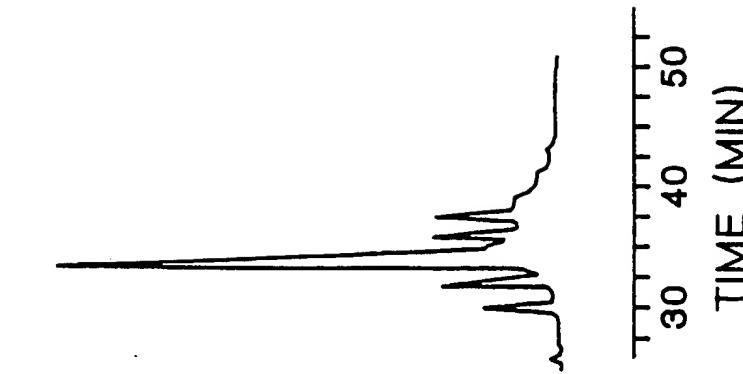


FIG. 11(c)

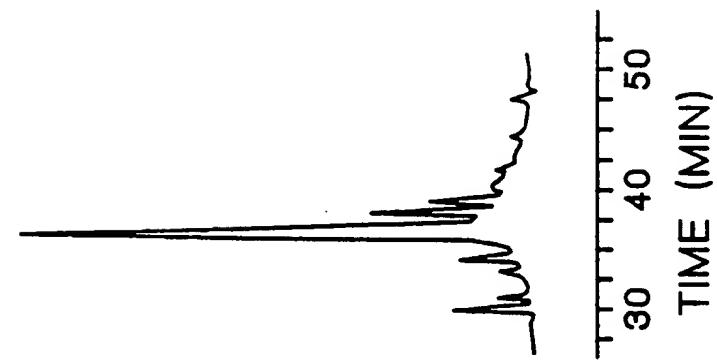


FIG. 11(b)

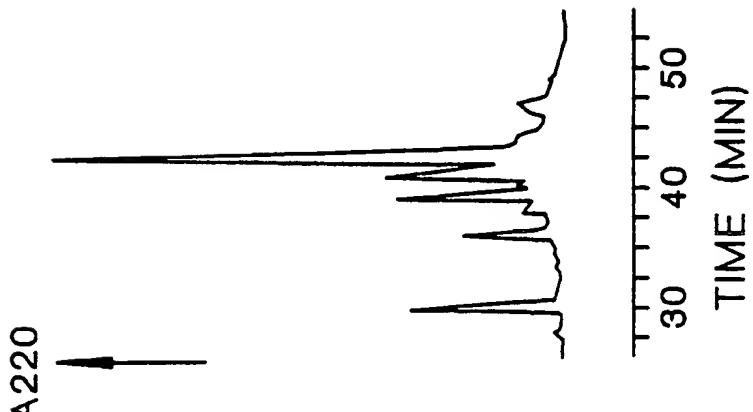


FIG. 11(a)

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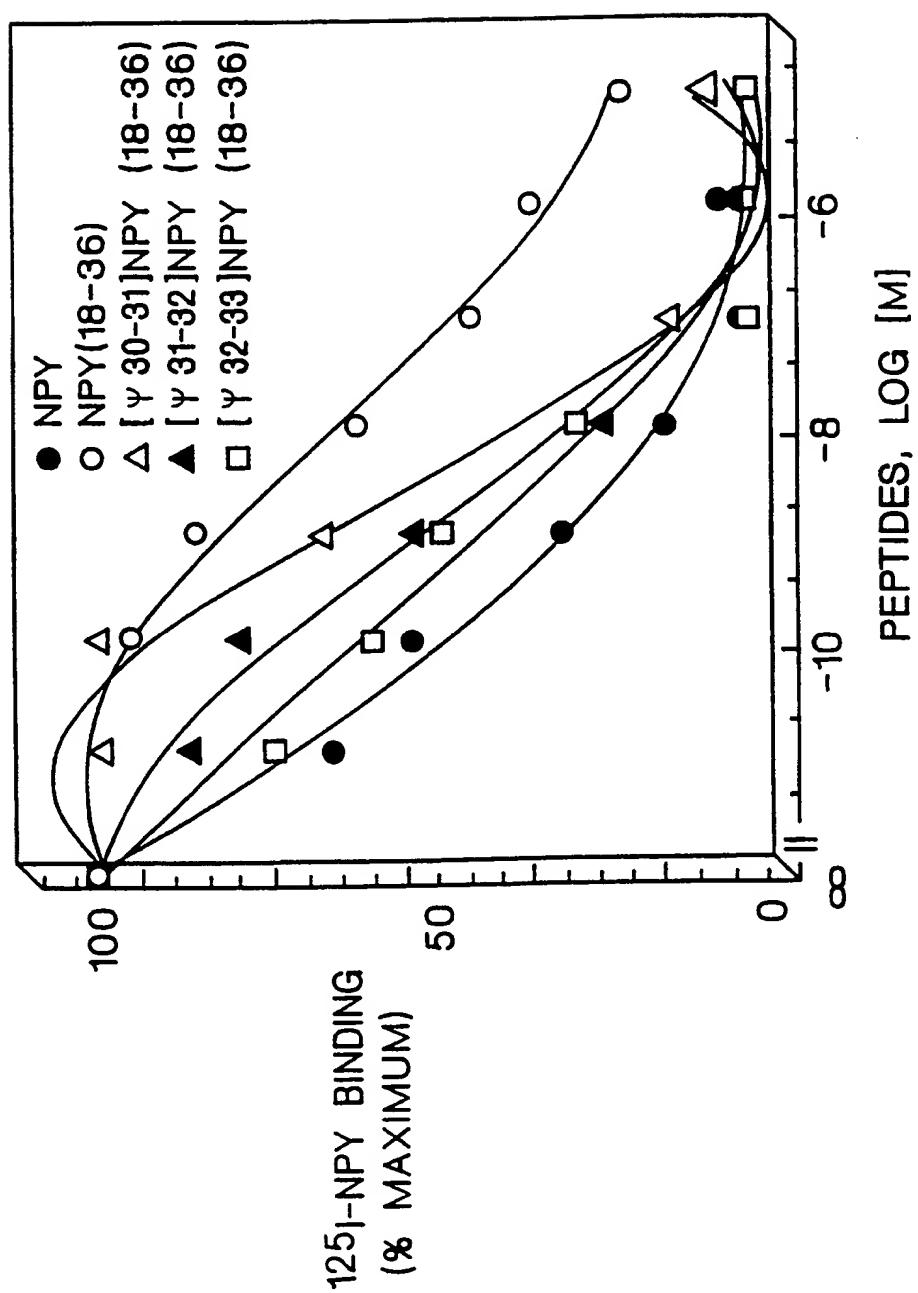


FIG. 12

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US94/06837

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A61K 37/02; C07K 5/00, 7/00, 15/00, 17/00  
US CL :530/324, 325, 326

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 530/324, 325, 326

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPTO APS  
search terms: neuropeptide Y

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 5,026,685 (BOUBLIK ET AL) 25 June 1991, col. 3, lines 20-35.	5, 6, 12
X	US, A, 4,839,343 (WAEBER ET AL) 13 June 1989, col. 1, lines 20-60.	1,9
X	EP, A,0,355,793 (KRSTENANSKY ET AL) 28 February 1990, see p. 2.	1,9
X	J. Med. Chem., Volume 36, Number 3, issued 1993, D. A. Kirby et al, "Defining Structural Requirements for Neuropeptide Y Receptors Using Truncated and Conformationally Restricted Analogs", pages 385-393, see compounds #4,5 and 17.	1,2,9

 Further documents are listed in the continuation of Box C.  See patent family annex.

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Date of the actual completion of the international search

08 AUGUST 1994

Date of mailing of the international search report

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SHEELA J. HUFF

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## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US94/06837

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	J. Med. Chem., Volume 35, issued 1992, R. D. Feinstein et al, "Structural Requirements for Neuropeptide Y18-36-Evoked Hypotension: A Systemic Study", pages 2836-2843, see compounds #1-3, 6-9, 12-15, 19-20, 22-27.	12
X	J. Med. Chem., Volume 32, issued 1989, Boublik et al, "Synthesis and Hypertensive Activity of Neuropeptide Y Fragments and Analogues with Modified N- or C-Termini or D-Substitutions", pages 597-601, see compounds 1-3, 5-6, 9, 11, 20-21, 23-24.	1
X	J. Med. Chem., Volume 36, issued 1993, D. A. Kirby et al, "Neuropeptide Y: Y1 and Y2 Affinities of the Complete Series of Analogues with Single D-Residues Substitutions", pages 3802-3808, see Table 1.	1

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